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Agricultural Engineering Makes Impressive New Strides — *Frank J. Zink*

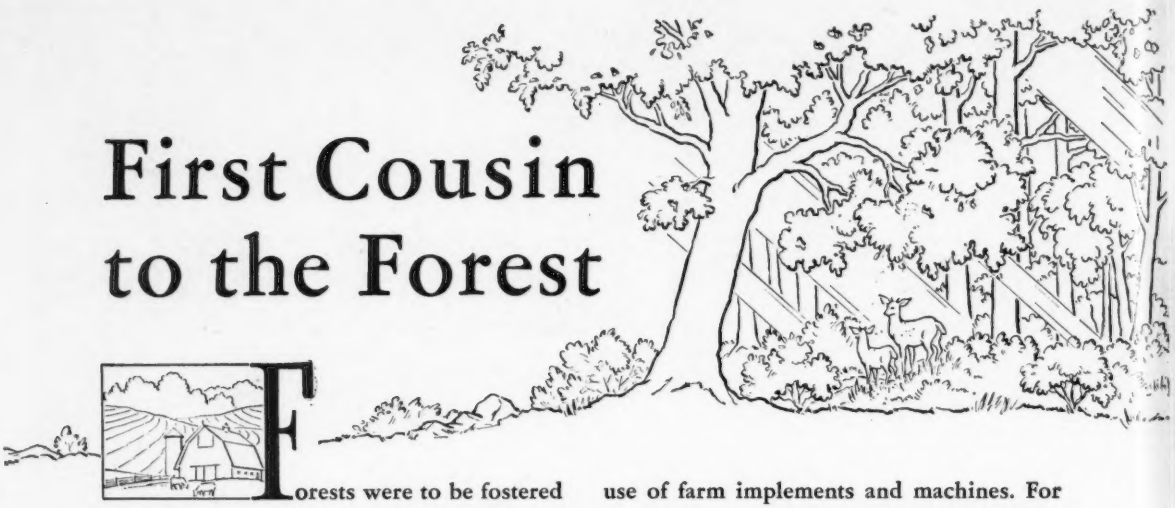
Some Results of Ice-Free Water Tank Research Studies — *Arnold M. Flikke*

A Belt Moldboard Plow Designed for Non-Scouring Soils — *Arnold B. Skromme*

Machinery Problems Involved in Utilizing Crop Residues for Mulches
Geo. B. Nutt, L. L. Harrold, F. R. Dreibelbis, J. H. Lillard, J. E. Moody, T. W. Edminster, E. R. Baugh, R. B. Hickok, H. Kohnke, I. D. Mayer, and L. W. Hurlbut

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

First Cousin to the Forest



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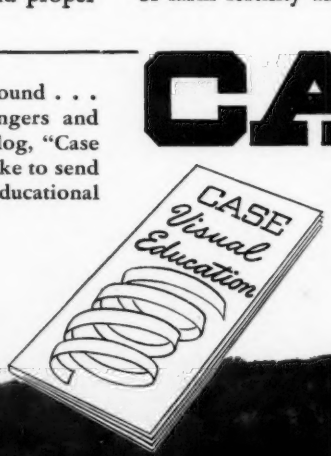

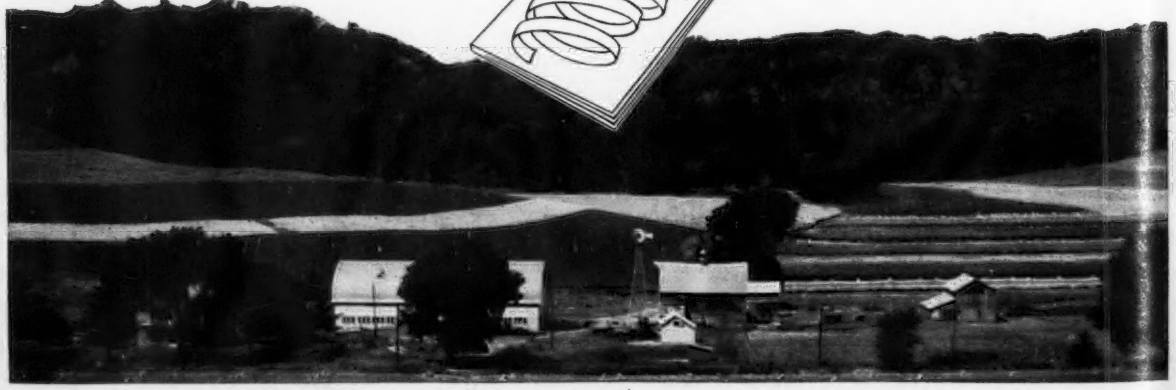

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SUBSCRIPTION PRICE: $4.00 a year, plus an extra postage charge to all countries to which the second-class postage rate does not apply; to ASAE members anywhere, $2.00 a year. Single copies (current), 40 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

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New York 17: BILLINGSLEA & FICKE
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EDITORIAL

Seven Producers

PRELIMINARY figures from the 1950 census show a continuing reduction in number of farmers in important agricultural areas, and in the proportion of our population engaged in agriculture. This is not surprising, considering increases in farm operating efficiency and in our total population. It carries some implications which seem worth reviewing.

Possibly only one of every seven or more people in the United States is now actively engaged in food production. The other six engaged in other activities depend on that one to keep their stomachs comfortably full.

This division of labor has advantages for all seven, when it works. It has worked. It is working fairly well now. It can continue to work. It is the only known basis for holding and increasing our material, intellectual, and humanitarian gains of the past 200 years.

But this division of labor and exchange of produced values is also more easily upset than the old system of each family producing its own food. Economic depression, recession, decrease in material welfare, increase in human suffering, and painful reversion toward family self-sufficiency, producing at best a bare existence, occur whenever efficient specialized production and exchange slows down materially for any reason.

Smooth and effective operation of this division of labor depends to some extent on its being understood by the people concerned—the one food producer, and the six more or less, who are engaged in other activities.

Here, for example, are some propositions on which we believe the one farmer and his six co-workers in other fields might well work toward a common understanding, to their mutual advantage.

Their division of labor is only an arrangement of convenience, a proven way of serving in different positions on one production team, so that each may share, as a consumer, a much larger quantity and variety of goods and services than he could possibly produce by himself.

Each of the seven has a dual function, as a producer of goods and services, creating supply; and as a consumer of values, creating demand.

The greatest source of wealth in the world is their continuing capacity to produce what they want by applying their energies to available natural resources.

Each of the seven must realize that the value of his specialized contribution to the production and consumption teamwork is governed by the economic law of supply and demand. The farmer must appreciate that his production of enough food for all seven is a fundamental economic service; that his production of enough additional food at low cost to provide an abundance is an added service; and that his production of an unusable surplus of any item is an expensive waste rather than a service.

In the present situation in which a high value is placed on human time, the farmer and the other six must realize that food items still requiring a large amount of hand labor can be produced only at luxury prices. Production of more of such items than the luxury market will absorb at luxury prices is misdirected effort. The six cannot be expected to pay the farmer for it. In turn the farmer who has not produced effectively what the six want, cannot be a good customer of theirs.

In the present situation of ample food, at a price, the farmer needs to have the other six work and produce so efficiently that they can afford to eat well, to consume large quantities of good food.

The six need to realize that the maximum economically storable surplus is at best only a small safety factor for their protection when low production occurs for any reason. It can be stored only at a cost, which must be shared by all.

In the present situation of ample food, the farmer and the other six need to appreciate the importance of increased facilities for storage of economically storable temporary surpluses, to provide a reserve of food for years unfavorable to high production.

The best food and economic security for all seven is in efficient agriculture, a high livestock agriculture, economic storage, and alternative outlets for surplus foods as industrial organic chemicals. Then the seven have four safety factors between them and famine whenever food yields are low. Less than normal yields will feed them. Stored reserves will be available to supplement their diet. Food stored on the hoof can be used as required. Products normally processed for industry can be diverted to food use. And temporary return to increased cereal and vegetable diet will stretch the food supply.

There are unquestionably numerous other aspects of their interdependence on which the farmer and the six others he feeds should work toward their mutual understanding.

Admittedly this seven-man picture of our economy and its problems is an over simplification. It is one which might be used to good advantage to clarify principles, promote understanding, and help all seven toward increased effectiveness in the teamwork on which their success depends.

Live and Let Live

ENGINEERING, along with many other phases of human activity and progress, thrives on the live-and-let-live principle in human relations.

This principle is the basic precept of freedom, of representative government, of human relations any step higher than those of serfdom and slavery.

Although ancient in origin, this principle is still far from universally accepted and applied. It is being relearned imperfectly and with painful difficulty, by each succeeding generation.

It has been tested by two world wars, numerous smaller conflicts, and on an individual scale by every person who has ever had the opportunity to indulge in a single voluntary act.

It appears that the Korea incident may mark the beginning of another major test of the principle. How long and difficult and expensive that test may prove remains to be seen. The ultimate outcome is assured by the fact that the laws of nature and human nature cannot be changed or entirely suppressed by being denied.

We may hope to have learned by the time that test is over, that there can be little mutual understanding between those who do and those who do not believe in the principle. There is no appeasement, no concession, no treaty which can protect anything from an aggressive predator. A predator respects only force and skill superior to its own.

Communism now seems to be the last remaining strong national threat to the live-and-let-live principle and the right to practice it by peoples who believe in it. When communist aggression has been stopped in its tracks; when its fallacies have been broadly exposed; when the peoples of inherently strong nations have found and accepted other leadership, what further major threats to human freedom will exist?

There will be some, and we cannot afford to deceive ourselves into believing otherwise.

There will still be men with leadership and organizing ability who do not believe in the live-and-let-live principle.

There will still be people with little respect for property rights, people who would rather live by any predatory means than by useful, productive work.

There will be new generations growing up and learning to try to make their way in this world in one way or another.

Engineers and engineering have a major stake in the live-and-let-live principle, particularly as it applies to their opportunity to study and apply the laws of nature to the maintenance of civilization and human progress. That stake implies an obligation to engineers to share in the perpetual job of helping each new generation to learn well the practical idealism of the live-and-let-live idea, the logic of obtaining the means of living direct from its primary source, productive work.

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for warmer, drier farm structures

Better health of livestock and poultry . . . better production . . . these are worth-while aims. Yet, before many months, cold and dampness will make many service buildings uncomfortable.

Warmth and dryness both can be improved effectively by proper window treatment. Check farm structures now to see what can be done to improve conditions before winter sets in.

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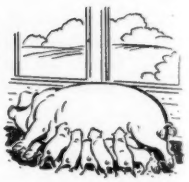

Dryness goes hand-in-hand with sunlight and warmth. In a warm barn the air takes up more moisture, carries it away.

WARMER BUILDINGS

Much warmth can be gained through large windows that are oriented to bring in winter sunshine. To *keep* both sun-generated heat and animal-generated heat inside buildings, windows should be insulated.

BETTER SANITATION

A well-daylighted barn is more sanitary. Not only does sunlight have a germicidal effect, a well-lighted interior promotes cleanliness. And insulated windows reduce germ-and-dirt collecting condensation. Use large panes to avoid dirt-catching, light-robbing cross members.

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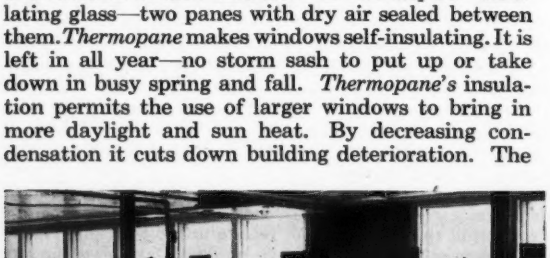

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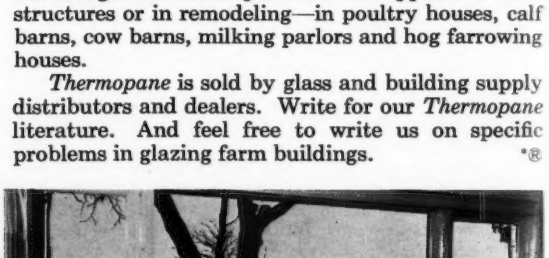

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AGRICULTURAL ENGINEERING

VOL. 31 AUGUST, 1950 No. 8

Agricultural Engineering Makes New Strides

Frank J. Zink
FELLOW A.S.A.E.

THE first event of importance to us as agricultural engineers was the establishment of our national society, the American Society of Agricultural Engineers. This is the 43rd annual meeting of our organization; next week it will begin the 44th year of its activities. I like to think of agricultural engineering as a constructive effort toward the application of the positive forces of engineering to the largest single industry in the world—agriculture.

Another event of historical interest in connection with the development of our professional society was the establishment of our monthly journal, AGRICULTURAL ENGINEERING. This event made our efforts in the application of engineering in agriculture much more effective.

The great majority of us had little to do with either of these two events. However, both of them have immeasurably affected our organization. As we now operate, they are the principal means, except our own individual efforts for developing the opportunities open to us, both as individuals and as a professional group. To some of those opportunities we have already applied ourselves. But there are others which are still untouched, and many more are yet to be revealed to us.

FRANK J. ZINK
President, A.S.A.E., 1949-50

In these remarks there are a few items which I am really called upon to report to you concerning our activities this past year. But along with them I should like to leave a few thoughts with you concerning our future and some of the things which should become activated.

During this past year I have sought to clarify our position with respect to federal research in agricultural engineering. As many of you know, I have talked at some length about the re-establishment of a bureau of agricultural engineering in the U. S. Department of Agriculture. However, in view of the editorial over my name in AGRICULTURAL ENGINEERING for June, it will not be necessary for me to discuss the matter in detail here. I now want to urge that we give our attention to this matter. The time is propitious for taking action. For all the details involved the editorial will adequately serve to inform you of the situation and need for action. But one thought may be added; as taxpayers we are, I am sure, interested in the most for our dollars and do not care to see two bureaus established, both of which deal with agricultural engineering. It is our desire to see the most effective organization possible set up, to the end that adequate agricultural engineering service may be rendered by the federal agency devoted to it.

With reference to membership and other organization matters, these have already been reported to you in the annual report you received from our headquarters office. I feel with some pride that we have accomplished a number of things this past year which will solidify our organization.

Within this year we have employed a new Assistant Secretary, Cernyw K. Kline. Membership expansion, increased section activities, more student sections, and larger meetings have all made this necessary.

It has been my privilege to attend a number of section meetings this past year. I am of the opinion that section meetings alone would almost keep one man busy attending to details of the meetings and attending the meetings themselves. I recommend to the membership that all section meetings have in attendance a representative from our headquarters office. It is a gratifying opportunity for the Society's president to attend these meetings whenever opportunity affords, but our membership strength lies in keeping closer contact between members and headquarters. In this recommendation, I am not unmindful of the membership loss this past year of 140 persons mostly due to resignation. Section meetings and section interest will tend to sustain our membership. Section meetings are highly important toward professional development in the future.

During the last week of May I had the opportunity of addressing a letter to W. Stuart Symington, chairman of the National Security Resources Board, suggesting that an agricultural engineer be placed on the general staff of the board. Through this recommendation we have the opportunity of discussing the matter further with Mr. Shields, director of the Production Office.

As some of you know, a recent bill approved by the President creates a National Science Foundation. This is an independent executive agency with a National Science Board of 24 members and a director, the Board to be appointed by the President with the advice and consent of the Senate and the director exofficio. The first appropriation for the fiscal year 1951 amounts to $500,000. Annually thereafter the appropriations will amount to $15,000,000. A number of deans of engineering schools have been looking to the establishment of this foundation as a means of starting significant engineering research at their institutions. I believe agricultural engineering has a very definite place within the scope of this work, and therefore a letter has been addressed to the President offering the assistance of our Society, as well as specifically suggesting an eminent agricultural engineer to serve on the National Science Board. This suggestion has been made so recently that there has not yet been time for a response. I believe that we may anticipate a possible member of this Board, or at least due consideration of our profession.

We are a small group of engineers by comparison; we barely number 3,000 persons. That means there would not be even one agricultural engineer per county in the United States, with possibly less than one trained agricultural engineer for each foreign country. In view of the work which we may do, the work we can do, the area to be covered and the service which is desired, we are an extraordinarily small group.

Within our group the majority of our members have just begun professional work. Good groundwork has been laid in

Annual address of the President of the American Society of Agricultural Engineers before the 43rd annual meeting of the Society at Washington, D. C., June, 1950.

The author: FRANK J. ZINK is consulting agricultural engineer, and president, Frank J. Zink Associates, Chicago, Ill.

these past 43 years for the application of the patterns of our work. I think it well to reemphasize that the ultimate usefulness of our profession lies in keeping firmly in mind the fact that our interest is in the several million farming units where our results are to be obtained. Objectives falling short of those farming units are simply not very useful.

Agriculture as it is practiced and as it is lived in our United States, and in most of the other countries of the world as well, is composed of a heterogeneous mass of family and small operating units. We cannot ignore the fact that many of these are not very economical units. Nor are they much beyond a mode of living. There was a time when we in this profession were not too rational in our integration of agricultural engineering to these units of agriculture. Let us bear in mind that for our greatest opportunity of service to agriculture we must be constantly aware that it is with these units we are most concerned.

Whatever may be the channel in which we work, whether it be private industry, education, public service, or service industries, the sole and ultimate outlet for our usefulness is on the farm itself. The farm operators and their families are our customers and our bosses.

Inasmuch as our society has doubled its membership in the past four or five years, I direct attention to those in educational work that this calls for sound job counseling of graduates. I say job counseling, for I prefer this to the more familiar placement service rendered by many colleges and universities. We should have among our graduating agricultural engineers a goodly number of men pointed to self-employment in pursuits nearer to the farms. Placement service in almost all instances points men to payrolls. There are ample opportunities for agricultural engineers on payrolls, but we have a companion need for men in the everyday farm application of agricultural engineering. I mean in farm management, farm construction, land and water services, retail merchandising of equipment and building materials.

If such avenues of service are not strengthened, we shall find that programs, research and improved practices developed by agricultural engineers in nation-wide operation activities will find slow, difficult acceptance and application on farms. A case in point is crop drying. The basic equipment and methods are available, but the barrier to broader acceptance and usage is a lack of adequate application agencies near to the farm but only a step removed from the farm.

It is obvious that we have more water systems, more tractors, more new types of structures, more sprayers, and more use of electricity, because retailers who serve farmers have become sufficiently acquainted with the technicalities involved to get the job done.

The engineering of installation, the engineering of equipment selection, and the engineering of equipment management can no longer be completed within the industrial plant. Within the decade past, we have many new angles of crop quality values, crop preservation and protection, storing, handling and processing which makes agriculture today much more complex. Likewise, the equipment, the structures, and the other phases of crop production become more complex. It is perfectly obvious that both the manufacturing and application ends of these newer methods must have adequate engineering.

The producers of farm supply items are finding that their products will fit agriculture better when they are engineered to the application. Such engineering cannot readily be incorporated into the product in sufficient amount to fulfill the needs at the point of use.

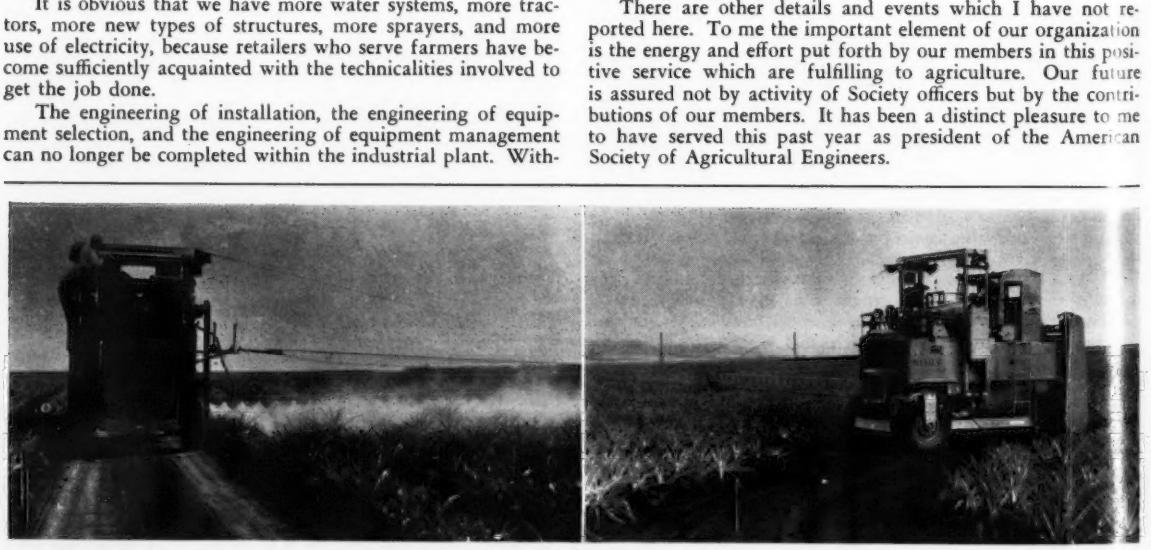
The full-line equipment manufacturer today is finding his line shortened in two ways. First, the basic machines must be produced in volume. Manufacturing economies produce this pressure to volume. Second, as agriculture increases in complexity, local and regional specialized equipment needs increase. This applies to other goods and services as well in agriculture.

Whether it be farms or factories, labor, machines, structures, and production materials are common to both. Management engineers of both must possess the same capacities. I wonder why we in agricultural engineering have so long overlooked the field of farm management. In all of my experience, I have found only one or two economists in a factory management job. To operate a factory, I doubt that the directors of any corporation would select an economist, for that capacity alone, to run their factory. It would appear that we as agricultural engineers have, as is so often done, overlooked the obvious. I recommend this for greater consideration by our members in educational work.

Agricultural engineering progress is reflected by applicable and suitable standards. We are making gradual progress along these lines particularly in farm equipment. I recommend to those of our members who are involved in needs for standards, which have not already been set up, to more actively and aggressively pursue their cause.

My attention has been called to the need for more standards in the field of farm structures. Minimum requirements have in part been established, but it would appear that there are still too many variants, possibly the result of lack of basic research. If basic research is needed before standards are established, I would strongly urge the pursuit of the most important items. Standards for farm structures should then follow as quickly as possible.

There are other details and events which I have not reported here. To me the important element of our organization is the energy and effort put forth by our members in this positive service which are fulfilling to agriculture. Our future is assured not by activity of Society officers but by the contributions of our members. It has been a distinct pleasure to me to have served this past year as president of the American Society of Agricultural Engineers.



As illustrated here, the Hyster straddle truck has been adapted for carrying spray equipment in pineapple fields (Hawaii) to treat growing plants with pest and parasite control solutions, iron sulphate, fertilizer, weed spray, and hormones. The machine steers on all four of its pneumatic-tired wheels and can thus negotiate sharp field turns. Seated side by side in a closed, air-conditioned cab, both the driver and spray boom operator have good vision of fields and roads. The boom is 65 ft long, and the entire boom structure folds alongside the vehicle to facilitate moving from one field section to another. The boom is raised and lowered by means of hydraulically operated cable controls and counterweights

Results of Ice-Free Water Tank Studies

By Arnold M. Flikke
JUNIOR MEMBER A.S.A.E.

ICE-FREE water for livestock has always been a problem for the livestock owner in northern climates. Water is the cheapest part of the livestock ration, yet during cold weather it is the most difficult part to supply in adequate amounts.

Various recommendations for keeping water ice-free have been suggested, such as the use of wood, coal, oil or electricity as sources from which to supply heat to the water. Although these heat sources have been found satisfactory, they do have the disadvantage of a high operating cost during the extended cold periods of our northern winters.

The over-all objective of the research reported here has been to promote the efficient use of electricity. If electricity can help make use of some other heat source for the solution of this ice water problem, it meets our objective, and possibly will prove to be an economical solution of the problem from the user's standpoint. Therefore, the problem of ice-free water for livestock was approached with the idea of finding what the heat requirements for a satisfactory watering unit are, and then heat sources producing an essentially constant temperature available on a farm were considered.

It is difficult to calculate the actual quantity of heat lost from an exposed liquid surface. Heat loss occurs through radiation and convection from the surface, and by mass transfer or evaporation of the liquid. The formula for the sum of these three phases is formidable as evaporation is an involved phenomenon and difficult to measure. Fig. 1 shows the result of work done by Friedman* in measuring heat losses from tanks and vats. The results have been plotted for 40, 50, and 60 F water subjected to 40 and 0 F air. The relative humidity was 70 per cent. Study of the illustration shows that each of the factors — air velocity, air temperature, and water temperature — affect the total heat lost from a tank. Friedman's results give a value of 300 Btu per hr per sq ft for 40F water subjected to air at 0 F and an air velocity of 16 fps. These conditions are typical of a cold Minnesota morning.

The heat lost from a tank is reduced as the drinking area exposed to the atmosphere is reduced. It is therefore desirable to keep the open water area at a minimum. Since Friedman's work was for large vats and kettles kept at a constant temperature, trials to determine the quantity of heat lost from a small tank were run. At the same time, the manner in which the temperature of the water changes as it cools and freezes was studied. A small insulated tank filled with water was placed in a walkin freezer and allowed to freeze. The air velocity was negligible and the relative humidity high. The surface area of the tank was 0.66 sq ft and the water in it weighed 40 lb. Thermocouples were placed at various depths in the water and temperature records taken with a recording device.

Fig. 2 shows the results of a trial in which the air temperature was 0 F. The water passed through two distinct phases, cooling and freezing, as the temperature dropped. The cooling phase will be discussed first as it is this part that determines the amount of heat needed to keep the water ice-free. In this trial the initial temperature of the water was 76 F and the first ten degrees of cooling are not shown on the graph. It is evident that there is stratification of the water at different temperature levels from top to bottom of the tank and that this layer formation of the water takes place as soon as the water begins to cool. The difference in temperature between these layers of water does not change appreciably as the cooling process continues even though there is continuous circulation of the water in the tank. The rate of cooling is approximately the same throughout the cooling period.

Calculation of the heat loss from this tank showed that the 40 lb of water cooled 25 F in 7 hr or at the rate of 3.6 deg per hr, giving a heat loss of 144 Btu. The heat loss is 216 Btu per hr per sq ft when converted to loss per unit time per unit area. Similar tests were made at 20 and 40 F air temperatures and the calculated results are as follows:

Air temperature, deg F	Heat loss, Btu/hr/sq ft
40	72
20	120
0	216

These experimental values compare favorably with those found by Friedman, if 50 F is considered as the average water temperature and 5 fps is taken as the air velocity over the surface of the small tank.

Having calculated the heat loss due to cooling of the water, a study was made of the changes in temperature of the water as ice began to form. It was found that the water temperature was 39 F at a point 8 in from the surface when ice was forming on the surface. A study of the physics of the freezing process brings out the fact that water reaches its maximum density at 39.2 F. In the freezing process, the lower layers of water soon reach this point of maximum density while the surface is much warmer. This is because the water, as it cools around the sides of the tank and at the surface becomes denser, settles to the bottom and displaces the warmer

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1949, as a contribution of the Rural Electric Division. Authorized for publication as Miscellaneous Journal Series Paper 698 of the Minnesota Agricultural Experiment Station, Project 114.

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*Friedman, S. J.: Heat Loss from Water Surface in Tanks. *Heating and Ventilating*, vol. 46, no. 4, p. 88 (April 1949).

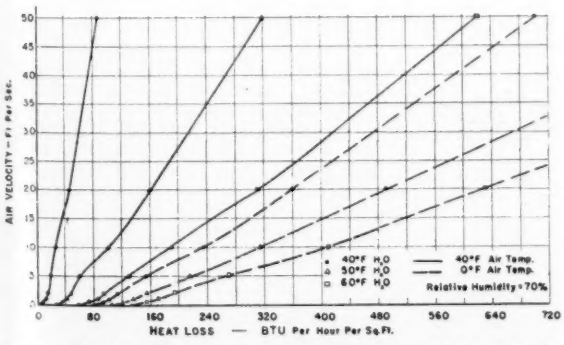

Fig. 1 Heat loss from water surface in tanks (Data from S. J. Friedman, E. I. du Pont de Nemours & Co.)

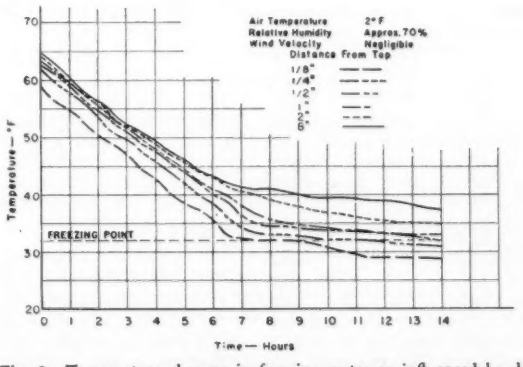

Fig. 2 Temperature changes in freezing water as influenced by depth, 0.66 sq ft of surface area

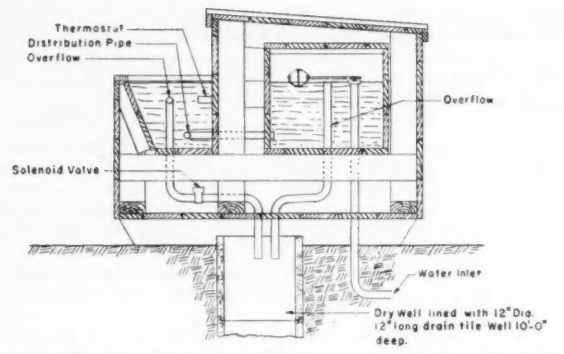

Fig. 3 Pipe line arrangement of frost-free stock watering tank (Scale $1\frac{1}{2}'' = 1'\ 0''$)

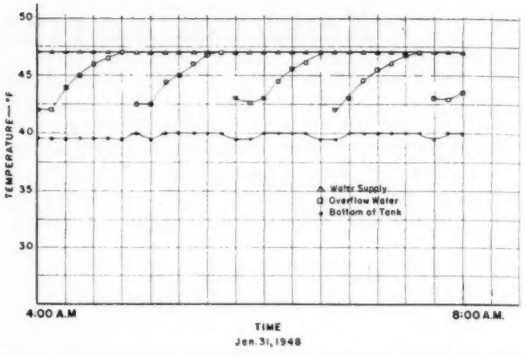

Fig. 4 Temperatures in overflow stock water unit. Air temperature, 7 F; wind velocity, 18 mph

water. This causes the water to circulate until the entire quantity of water is 39.2 F. Upon further cooling the surface water cools but being lighter stays on top and will eventually freeze.

The conclusion from this part of the study is that the coldest water is on the surface of the tank and if 39 F is suitable for livestock one need only be concerned with the top 2 or 3 in of water in keeping a tank ice-free.

Investigation as to the optimum water temperature for livestock led to the conclusion that cattle do not particularly prefer warm water. In fact, they will drink more water if the icy chill is off, or the temperature is between 35 and 50 F. The important thing is that water must be available at all times.

Based on these facts, a tank was designed which allowed the cold surface water to be drained off and replaced with fresh water from the well. Here advantage was taken of both sides of the maximum density point. This behavior of water causes ice to float and also causes water warmer than 39.2 F to rise to the surface. Thus one is able to remove the cold water from the surface and replace it with warm water which rises to the top of the tank. In this method the earth is utilized as the source of heat to prevent freezing in the tank and electricity is used as a means for controlling the overflow.

The amount of overflow was controlled by a solenoid valve which is opened and closed by a thermostat. Referring again to Fig. 2, if the thermostat is located 3 in below the surface of the water, the setting of the thermostat ought to be 42 F due to the difference in temperature at the two water levels. This setting should open the solenoid valve just before the tank begins to ice over on the top.

A cross section of a unit of this type is shown in the Fig. 3. The insulated float chamber was connected to the water supply and to the drinking area. Water flowed from the float chamber by gravity to the drinking area where it was distributed evenly over the area by a distribution pipe. The overflow entered a waste pipe and passed through the solenoid valve into the drain. Two requirements for this type of unit are an automatic supply of water and good drainage facilities.

The unit built first was operated in an open pasture with no livestock drinking from it. This should represent the most severe conditions under which it would operate. Fig. 4 shows four hours of operation of the unit. The waste-water temperature fluctuated between the thermostat setting and the well-water temperature. Records of the quantity of water allowed to overflow were kept during the months of January, February, and March. Values for the amount of water wasted and the average daily temperature for the last two weeks of January are given in Table 1. The value, 414 gal on a –16 F day, was the maximum recorded. The drinking area did not freeze solid during this period, but did have ice on the surface several times. This ice could have been easily broken by the cattle.

The amount of heat contained in the water supplied to the tank on the day when 414 gal were wasted was approximately 17,000 Btu. This quantity of heat would keep the tank open if the average loss did not exceed 240 Btu per hr per sq ft of surface area.

Three units were operated during the winter of 1949 with cattle drinking from them. This resulted in less wasted water due to the animals drinking. The water wasted reached a maximum of 264 gal per day per unit. The average daily water usage for the 3 units was 130 gal. Data as to the amount of water wasted for a 10-day period by a unit at University Farm are shown in Table 2.

The amount of water needed to keep these units open each day can be supplied with 2 kw-hr or less, the cost of which is considerably less than for methods now being used.

From these studies it seems that one should be concerned with supplying heat to the top 2 or 3 in of water in a suitably designed stock water tank. This conclusion has led to a study of other means of supplying heat to this top layer of cold water as the overflow heating *(Continued on page 390)*

TABLE 1. OVERFLOW TANK HEATER DATA

(North Pasture, University Farm, 1948)

Date	Average air temperature, deg F*	Water "wasted", gal
January 16	–15.8	263
17	–11.7	173
18	– 2.4	159
19	–10.0	154
20	5.7	245
21	–11.8	299
22	–16.6	394
23	–10.4	226
24	5.5	194
25	2.7	217
26	–16.5	414
27	–13.2	356
28	12.8	231
29	12.6	141
30	8.9	190
31	14.5	163

* The temperature for each day is the average of 48 automatically recorded values.

TABLE 2. DATA OBTAINED AT BEEF BARN, UNIVERSITY FARM, 1949 (18 head of cattle)

Date	Air temperature, deg F*		Meter, gal†	Time overflow, hr‡	Water "Wasted," gal
February 9	17	–8	164	3.1	93
10	12	–4	208	4.2	126
11	35	8	121	1.9	57
12	33	5	166	3.9	117
13	7	–8	159	4.0	120
14	11	–14	227	6.1	183
15	31	2	120	2.2	66
16	21	3	158	3.0	90
17	36	3	107	1.4	42
18	34	10	111	2.2	66

* Data obtained from Minneapolis Weather Bureau records.

† Total gallons of water entering watering system.

‡ Overflow rate was 30 gph.

A Belt Moldboard Plow

By Arnold B. Skromme
MEMBER A.S.A.E.

LAND used for pineapple culture in Hawaii presents a very difficult plowing problem because of three main factors:

1 The soils upon which most of the pineapples are grown are clays of volcanic origin, usually well aggregated. These soils do not scour because of the low shearing strength resulting from this aggregation and their very high adhesive property. In general more than 90 per cent of the particles are less than two microns in diameter.

2 The surface layer of crop residue (hereinafter called trash) is tough and fibrous, and weighs from 60 to 120 tons per acre green weight, averaging about 85 tons (Fig. 1).

3 In planting operations the usual practice has been to prepare the soil to a near powder-like consistency with the trash buried at least 5½ in deep, and with a loose seedbed depth of 12 to 18 in.

Power and Labor Data. Plowing non-scouring soils has always been a tedious task. At the time plow-design research was started by the Pineapple Research Institute of Hawaii in late 1947, preparation of the pineapple seedbed required an average of 13.7 trips over the field with large track-type tractors, as shown in Table 1. To the expenditures of machines, labor and power must be added the expense of lost time and the lost use of the land. These operations required from 6 to 12 mo, and increased the 3-yr growing cycle to a 3½ or 4-yr complete cycle.

The 1073 dhp-hr per acre required to prepare a pineapple seedbed is about 50 times as large as the 19.3 dhp-hr required to prepare a seedbed for corn in Iowa.

The average of 17.4 man-hours per acre to prepare a pineapple seedbed is, however, only about 10 times larger than the 1.72 man-hours expended for corn in Iowa because of the larger tractors, 60 to 120 hp, used.

An analysis of these figures shows that the problem of handling the trash, that is, knockdown and additional plowing and harrowing, consumes nearly one-half the work of preparing the seedbed, while only about one-fourth the work can be attributed to the non-scouring quality of the soil. Even though the plants are treated in a knockdown process, they are being further reduced in size during the first two or three plowings (Fig. 1). In other words, if there were no trash, the seedbed could be prepared without any knockdown, and with two-thirds or less of the plowing and harrowing. Furthermore, regular 32-in diameter disk plows and other standard tools could be used.

The three basic methods of soil tillage by mechanical means are probably cutting, crushing and lifting and letting soil fall on itself.

The plowing operation is especially efficient in loosening soil, and that can only be done mechanically by lifting the soil and letting it fall on itself. The problem in Hawaii was to design a plow that would bury the trash and loosen the soil as efficiently as possible, preferably in a once-over operation. This would result in maximum savings in both time and operating costs. Ordinary moldboard plows do not scour in Hawaii, even in the first few feet of operation. Disk plows with scrapers keep free of large accumulations of soil, but they cannot penetrate the thick layer of trash, and have to be used repeatedly to obtain a satisfactory plowing job (Fig. 1).

The pineapple planting materials are hand planted, and are thrust into a partial hole made by a trowel-like tool. Workers can plant faster if the soil is fine enough and dry enough to flow around the base of the plant after the tool is removed from the ground.

It was felt desirable to retain the advantages of the plow share with its suction point to obtain penetration and its share edge to shear off a slice of soil. The high soil pressure on the share keeps the soil accumulation down to a layer from ½ to 2 in thick, which does not prevent the inversion of the furrow slice. Two large problems then remained: (a) replacing the moldboard with a device that would lift and invert the soil slice to cover the trash, and (b) clearing a path through the trash for the plow beam.

Plow Moldboard Design. The following four methods of providing a scouring moldboard surface were considered:

1 Replacing the moldboard with an endless rubber belt (Fig. 2). The basic principle of the belt moldboard was first set forth in patent number 210,201, issued to Thomas Jefferson in 1878, although it was generally schematic in design. However, neither this plow nor subsequent attempts to use the belt moldboard principle achieved commercial success.

2 Replacing the moldboard with screw flights, with either horizontal or vertical shafts. Suggested in numerous patents. These screw conveyors, of course, would not completely scour in Hawaii, but they could throw or agitate the soil in the general direction desired.

3 Heating the moldboard, as shown in A. W. Tucker's early patent number 213,149, dated March 11, 1879.

4 Replacing the moldboard with a disk that revolved and could be scraped free of soil at each revolution, first covered in patent number 5,218 issued to George Page in 1847. The fact that one-half of the disk has a downward motion and the other half an upward motion made it appear that a plow with a movable surface going only upward and outward might prove more practical. And endless belt would give this type of motion.

Although all of the above methods were given at least a preliminary trial by the Pineapple Research Institute, only the first one will be discussed in this paper.

The substitution of a flat belt in place of a curved moldboard necessarily called for compromises in design. Doner and Nichols(2) and Kummer(3) have discussed the complex shape of the plow moldboard. Since the belt could not be curved because of its width and shortness, the soil had to be lifted high enough and carried toward the furrow far enough

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1949, as a contribution of the Power and Machinery Division, and is published with the approval of the Director of the Pineapple Research Institute as Technical Paper No. 194. (NOTE: A U. S. patent has been applied for on the plow described in this paper.)

The author: ARNOLD B. SKROMME, formerly agricultural engineer, Pineapple Research Institute of Hawaii.

AUTHOR'S NOTE: The author wishes to acknowledge assistance received from Dr. E. G. McKibben, head, agricultural engineering, Pineapple Research Institute, for help given in preparing this paper.

* Numbers in parentheses refer to the appended references.

FIG. 1 A conventional, heavy 32-in, 5-disk plow in use for first plowing a pineapple field with second and fourth disks removed

TABLE 1. PINEAPPLE SEEDBED PREPARATION BY CONVENTIONAL METHOD*
(Reports from Six Plantations on Four Islands)

Operation	Usual tool†	No. times over field Average	Range	Forward speed, mph	Actual acres per 8-hr shift (once over)	Dhp-hr per acre Average	Range	Man-hours per acre Average	Range
Knockdown	Stump cutter (flat-blade disk, 4 tandem axles)	3.5	1-5	2.6	12.4	256	147-440	4.27	1.33- 8.00
Plowing	Five-knife, 32-in disk plow	4.2	2-6	2.2	7.1	472	217-587	8.17	4.34-13.32
Harrowing	Multiple tandem disk harrows	4.8	3-7	2.7	17.2	239	94-440	3.69	0.85- 7.92
Subsoiling	Five-knife subsoiler	1.2	0-3	2.3	8.0	106	0-244	1.31	0 - 2.60
Total		13.7				1073		17.44	

* Does not include paper laying, fumigation and fertilizing operations
† All pulled by large track-type tractors

to invert itself by rolling down into the furrow because of gravity and the momentum of the soil.

An endless and quite flexible rubber belt, 24 in wide and 60 in in circumference, was mounted on 3½-in diameter rollers with tapered roller-bearing mountings. The belt was ¼ in thick and made from 3 plies of 20-oz duck with complete rubber surfacing. One roller was mounted at each end of the belt and one in the center. Five V-section ribs, similar to B section V-belts, were vulcanized on the inside of the belt, one on the belt center line and two on each side at distances of 5 and 9 in from the center line. These ribs ran in sheaves in the rollers, and were found necessary to keep the belt in position. It was also found necessary to use a carefully fitted scraper to keep the lower roller clear of soil.

Tapered rubber cleats about ½ in square were vulcanized to the outer surface of the belt at 3-in intervals to assist in lifting the soil. A shield was placed over the inner edge of the belt to keep soil from entering the inside of the belt. A large steel moldboard wing was extended out beyond the belt to keep the soil from rolling back down into the furrow behind the plow. This wing also served to keep the soil tumbling forward and outward, and assisted in covering the trash.

The total area of the belt and the steel stationary share, shield and moldboard wing that contacted the furrow slice was 1,790 sq in. Of this amount, only 642 sq in, or 36 per cent, of the area was taken up by the moving face of the rubber belt. These figures are not completely indicative of the scouring ability of the plow, as the area occupied by the belt was the most difficult to scour and most important in the lifting and inversion of the furrow. Most of the area of the station-

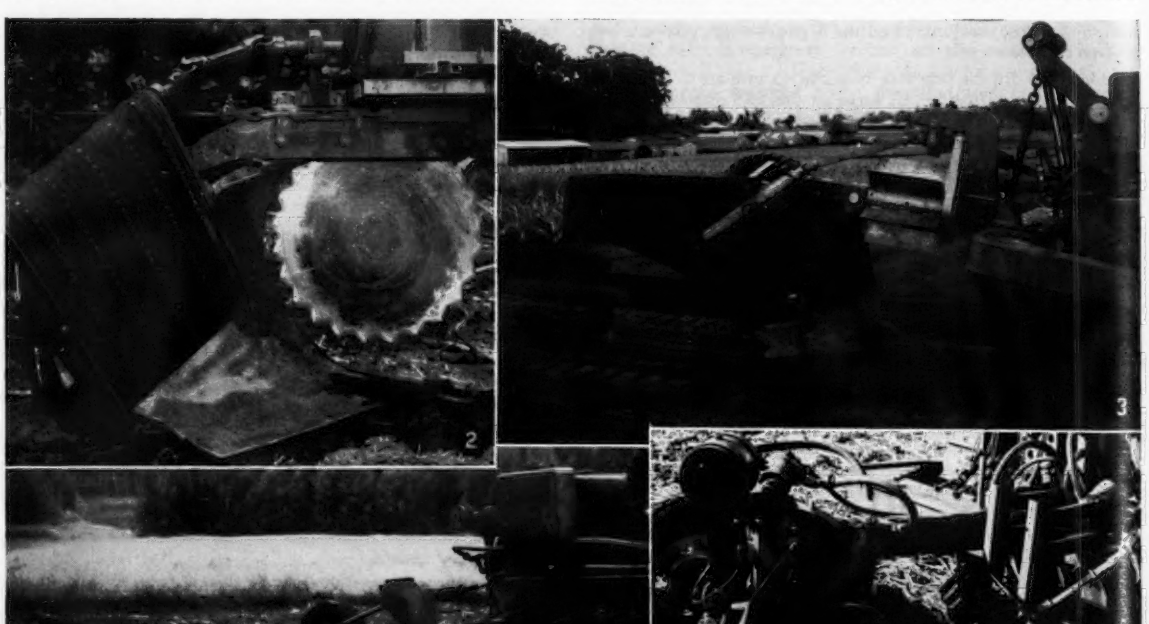

Fig. 2 Experimental PRI plow. Note belt moldboard and notched colter. Colter was power-driven by chain and sprocket back of colter • Fig. 3 Plantation model PRI plow mounted directly on U-type hitch frame and with beam-circumscribing rotor rather than power-driven colter • Fig. 4 PRI belt moldboard plow in action; note excellent soil tilth and coverage of heavy trash • Fig. 5 An experimental conveyor for moving trash into the furrow

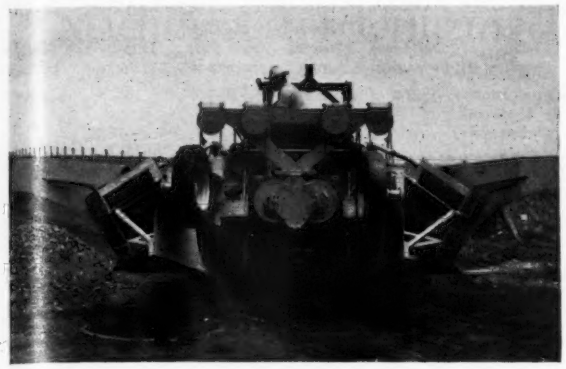

Fig. 6 Two-way model of PRI belt moldboard plow. Each bottom mounted on L-type hitch frame

ary steel was occupied by the share and the wing extension; the share did little lifting, and the moldboard wing served mainly as a buffer plate to keep the soil tumbling over the trash.

The comparison between the angle of the belt and the angles of a regular moldboard plow will be viewed from three positions — plan view, front view and side view. In a plan view, the angle made by the intersection of a horizontal plane passing across a regular steel moldboard is roughly 45 deg from a line parallel to forward travel. This is about the same angle as found on most share-cutting edges(3). The endless belt was first placed at this angle, but loose soil had a tendency to slip around the belt horizontally before it was lifted far enough vertically. The outer (furrow) edge of the belt was then moved forward until it made a 50-deg angle, which caused more of the soil particles to be lifted higher before inverting into the furrow. The share edge remained at 45-deg. Although no comparable drawbar tests were made at the time this change was made, it appeared that the flatter angle resulted in a slight increase in draft. Of the three angles defining the belts position, this one most closely approximated the corresponding angle of the steel moldboard. Nichols and Reed (4) and Bacon(5) have also shown that soils of low shear value need bluff moldboards, as gently sloping moldboards do not permit the furrow slice to be properly supported by the undisturbed soil in front of the plow.

In a front view, the line formed by the travel of a soil particle across the moldboard of a regular plow rises slowly across the share, changes quite abruptly to a new vertical line, holds nearly horizontal, and then drops as the soil falls into the furrow. It was desired to have the belt carry the soil particle as close to its line of natural travel as possible to eliminate relative motion between the belt and the soil slice. With the plow cutting a furrow slice 13 in deep and 32 in wide and depositing the soil in a fluffy layer 23 in deep (including trash), the soil particles would travel over different paths. These would vary from a particle lying at the tip of the share point, which would travel about 36 in upwards and about 60 in outwards at an average angle of 31 deg above horizontal, to a particle at the outer edge of the share that would be lifted about an inch upwards before it would fall back onto the furrow floor. A particle in the center of the plow and at the bottom of the furrow would travel about 30 in upwards and 30 in outwards before beginning to fall, at an average angle of about 45 deg.

The outer edge of the belt was tipped down 34 deg, so that a particle on the face of the belt traveled upward and outward on a line 56 deg above horizontal. It was believed more important to lift the soil when plowing heavy trash than to carry it sideways, as a considerable amount of soil must be elevated on top of the trash.

This 34-deg movement on the belts' face length of 28½ in would mean that a soil particle carried by the belt would travel 15.9 in toward the furrow if the belt were not also slanted back 40 deg from a line perpendicular to forward travel. This latter angle reduces the 15.9 in to an actual lateral movement of 12.2 in. Tipping the belt down further would have been desirable from the standpoint of soil-particle motion, especially at the top of the belt, but it was impractical because of the greater area of stationary non-scouring moldboard that had to be substituted between the plowpoint and the inside lower edge of the bottom of the belt.

Small numbered blocks placed in the ground showed that soil was moved an average of about 39 in horizontally, measuring the distance at right angles to the furrow. Thus the belt itself moved the soil only one-third of this distance. Sliding of the soil along the belt and steel surfaces due to the plow wedging action and the angular tumbling of the soil accounted for the balance of the movement. Ashby(6) found that the soil plowed by an 18-in plow moved an average of 20 in laterally, or 11 per cent more than the width of cut, compared to the 22 per cent increase found with the belt plow.

The belt plow also moved the soil from 1 to 52 in forward, averaging 36 in, and 5 in upward (because of the trash and general fluffiness of the soil). Thus the resultant of this 39-in lateral, 36-in forward and 5-in vertical movement was 53.4 in, or 4.45 ft. Ashby found that the 18-in moldboard plow carried the soil from 1 to 34 in forward, averaging 16.3 in. It also left the soil about 1 in higher after plowing. This 16.3-in forward, 20-in lateral and 1-in final vertical movement gave a resultant of 25.8 in.

This plow, operating at 2½ mph and plowing 13 in deep and 32 in wide, has to handle soil at the rate of 23 cu yd per min, or 1400 cu yd per hr (plus trash). Moving this volume an average distance of 4.45 ft means moving soil at the rate of 6,230 cu yd-ft per hr. This carrying of soil naturally affects the power requirements. Any reduction of this distance would reduce the draft, and probably a criterion for evaluating any plow would be the distance it carried the soil before it was inverted.

The belt was also tipped backward in a third direction. When viewed from the side, a vertical plane passed through the regular steel moldboard forms a line which is highly curved. The belt was not curved, but it was tipped backward 4½ deg from vertical.

The first trials of the belt moldboard plow were made without supplying power to drive the belt. Although the soil pressure and motion did rotate the belt, its speed was enough less than that of the soil to cause trash to rise as fast as the soil. This resulted in poor covering. When plowing at 2½ mph or 220 fpm, power was applied to the belt to drive it at a lineal speed of 310 fpm. This speed elevated enough soil above the trash to give fair coverage. The plow had to be operated from 12 to 14 in deep before enough soil was elevated to bury the trash at least 5-in below the surface. Tests conducted on mainland scouring soils with regular moldboard plows showed that they will not cover a 3½-in layer of trash, but that they make a sandwich of trash between the furrow slices which tend to stand on edge in heavy trash. It had been hoped, from a power standpoint, to make the belt efficient enough to invert the furrow over the trash when plowing only 10 in deep. Actually pineapple culture as presently practiced uses a seedbed that is loose to a depth of 12 to 18 in, so the extra plowing depth resulted in this type of seedbed without the use of the common subsoiler. The total depth of the freshly plowed furrow is about 23 in, but it quickly settles to about 16 or 18 in.

The life of the rubber belt has varied from 40 to 100 acres. At the present price of $75 per belt, the belt cost per acre has averaged about $1.25. Rock damage to the belt has been slight. The belt usually fails by progressive tearing after a small tear has been formed at the edge of the belts.

The horizontal and vertical beams of the plow are made from two 1x6-in mild steel bars spaced 1 in apart. The Hawaiian fields have numerous buried boulders, and a pivot joint had to be designed between the two beams to permit the lower, vertical, beam to swing backward and upward after striking an obstruction. A ¾-in mild-steel bolt is encased in hardened sleeves to act as a shear pin, and placed 8½ in behind the 1¾-in pivot pin on the center line of the top hori-

zontal beam. Under ordinary conditions an average of about two pins are sheared per day, but in one field 40 were sheared in 8 hr.

The 32-in high-carbon steel share is the same as used on the Post Brothers large plow which cuts a furrow 6 ft deep and requires four Caterpillar D-8 tractors to operate it. The only change made in this share for the belt plow is that the point is reinforced on its underside by a ¾-in steel plate.

The horizontal plow beam is suspended from an L frame or U frame mounted on a track-type tractor. A large jaw or clevis permits lateral swing of the plow, and vertical adjustments are made between the jaw and the beam. The L frame was designed in Hawaii a number of years ago and is unique in principle. It permits an L frame to be mounted independently (Fig. 6). The draft on this frame is taken by a large flat mild-steel bearing on the end of the frame attached to the center of the track frame. The back inside end of the frame slides on a ¾-in plate extended from the rear of the tractor to resist side thrust and bending.

TABLE 2. PRI BELT PLOW EXPERIMENTAL TEST FIELD OPERATIONS DATA*

Operation	Tool used	No. times over field	Forward speed, mph	Actual acres, 8-hr shift (once over)	Dhp-hr per acre	Man-hr per acre
Knockdown	Stump cutter (flat blade disk, 4 tandem axles)	2.0	2.1	10.4	169	2.30
Plowing	PRI belt plow	1.0	2.2	3.0	162	5.56
Rotary tilling†	5-ft rotary tiller	1.0	1.6	5.6	136‡	1.33
Total		4.0			467	8.89

* Does not include paper laying, fumigation and fertilizing operations.

† Or other secondary seedbed tool.

‡ Includes 60-hp engine on tiller.

Handling Trash When Plowing. Five methods of handling the trash were considered:

1 Cut a path for the beam with a notched colter, and plow deep enough to bury (Fig. 2).

2 Part a path through the trash for the beam only without cutting, and plow deep enough to bury (Figs. 3 and 4).

3 Part a path through the trash, and move all the trash into the furrow before the soil slice is inverted upon it (Fig. 5).

4 Chop all the trash into small pieces under 2 in in length to (a) eliminate the necessity of powering a colter, and (b) eliminate the necessity of burying all the trash to avoid planting difficulties.

5 Burn the trash.

Method 1 was first tried with a 33-in free-rolling colter, which became jammed every 3 ft of travel. Power was then applied to rotate a 28-in notched colter at 90 rpm, and this worked very satisfactorily in fields without numerous rocks. The power requirement of about 13 hp was quite high, and its construction and maintenance was expensive.

Method 2 was accomplished by using a very simple beam-circumscribing rotor, which has now replaced the powered colter. When the plow is pulled through the soil, the trash will partially tend to part itself because of the boiling action of the soil above the share point. However, some trash will rise up the vertical beam to the horizontal beam. The rotor completely surrounds the beam and is powered and equipped with paddles to part the trash and move it a few inches toward the furrow (Fig. 4).

Method 3 was accomplished by dragging the trash into the furrow with slats and fingers attached to roller chains. This worked very well, but its higher cost prevented its general acceptance (Fig. 5).

Method 4 is being investigated and method 5 is to be avoided.

Power and Labor Requirements. Two drawbar tests of the plow show that the drawbar force required to pull this plow operating 13 in deep and cutting a furrow 32 in wide is 5,200 lb, or 12½ lb per sq in of furrow cross section. The power to operate the belt is about 4 hp, and the power to drive the beam trash rotor is about 5 hp. When this additional 9 hp is converted to equivalent drawbar pull at 2½ mph, the draft is increased by 1,350 lb, raising the draft per square inch of furrow cross section to 15¾ lb. Most of the plows are mounted on D7 Caterpillar tractors, which handle a single bottom very satisfactorily.

The data in Table 2 show that this new plow might reduce the power and labor requirements considerably if the final plantation tests substantiate the experimental data. The number of trips over the field is reduced from 13.7 to 4.0, the work is reduced 56 per cent to 467 dhp-hr per acre, and the labor is reduced 49 per cent to 8.9 man-hours per acre. Better trash-handling mechanisms now under development should not only make plowing easier, but should also further reduce the total power and labor requirements.

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Ice-Free Water Tank Studies

(Continued from page 386)

method has the disadvantage of requiring good drainage facilities for the waste water. One method now under investigation is passing the water from the tank through coils buried in the ground. Reports of other investigators indicate that approximately 6 Btu per hour for each square foot of soil surface and each degree of temperature difference between the soil and the water in the coil can be obtained from a sandy soil. This heat value increases with the higher thermal conductivities of such soils as wet clay. Intermittent circulation of the water will also increase the rate of heat transfer to the water from the soil.

Another source of heat to be studied is the fermentation of the accumulated manure in pen-type barns. Results of studies at other stations show that the temperature ranges from 80 to 100 F in the manure pack of this type barn. In future experiments it is planned to use the manure pack as a source of heat for keeping the water tank open.

Engineering Frontiers

WHAT is true of the trades is even more true of opportunities for engineering employment. A few persist, but with advances in technology and science and with the ever-increasing acceptance of the engineer as a man able to turn his skill to almost every aspect of industry and business, opportunities for engineers multiply.

This is indeed a fortunate circumstance, particularly in times when, like the present, the new crop of engineering graduates may be too large to be absorbed in the traditional patterns of engineering practice. For the need presses us to expand the frontiers of engineering, to invade non-traditional fields, and to seek opportunities in the new ones which scientific progress will bring forth.—From an editorial in *Mechanical Engineering* for July, 1950.

Machinery for Utilizing Crop Residues for Mulches

By George B. Nutt
MEMBER A.S.A.E.

THE average annual rainfall in southeastern United States varies from 45 to 80 in. The heaviest rainfall is in the mountains and near the coast with the extreme conditions in the mountain area. Although this abundance of water is an asset in many respects, it presents a serious problem in the form of soil erosion on much of the cultivated acreage. The rainfall is not evenly distributed, with the result that there are wet seasons and droughts of sufficient duration to affect crop yields because of the low water-holding capacity of most of the soils. The greatest soil and water losses occur during rains of high intensity and the southeastern quarter of the United States has the highest intensities in the country. As much as 30 in in a single month and 10 in in 24 hr have been recorded in certain areas. Storms of great intensity strike most often during the summer months when the cultivated areas are most susceptible to erosion.

In the Piedmont soil provinces and similar areas, much of the land is steep and rolling. Under conventional practices of clean cultivation, the infiltration capacity of these soils is low. Thus, heavy and intense rainfall, combined with rolling topography, erodable soils and clean tillage practices produce an erosion problem of great magnitude.

Since 1942 the South Carolina Agricultural Experiment Station, in cooperation with the Soil Conservation Service (USDA), has investigated the use of mulches for the control of runoff and erosion. This work involves engineering, soil science, and agronomic aspects. The experimental work has been concentrated at Clemson, located in the upper Piedmont.

Soils of the Piedmont province are predominantly heavy and contain many rocks of sufficient size to interfere with the operation of machinery. Most of the cultivated areas are sloping, ranging from slopes of less than 1 per cent to 10 or 12 per cent. Cleared land of greater slope is often cultivated, but usually is utilized for pasture. Fields are relatively small. For instance, the average South Carolina farm contains about 28 acres of land under cultivation, usually in many fields. Practically all of the upland is terraced and cultivated on the contour. All of these factors influence the development and adaptation of machinery.

In a preliminary experiment reported by Peele* from studies made near Spartanburg, S. C., in 1941, an artificially applied mulch materially increased the yield of corn, conserved moisture, and reduced erosion. These beneficial results led to establishing a project which included the machinery problems involved in a system of farming which would utilize plant residues on the soil surface during the growth of row crops and small grains.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1949, as a contribution of the Soil and Water Division.

The author: GEORGE B. NUTT, head, agricultural engineering dept., Clemson Agricultural College, Clemson, S. C.

* Peele, T. C.; Influences of Mulches on Runoff, Erosion and Crop Yields. South Carolina Agricultural Experiment Station Annual Report (1942).

TABLE 1. EFFECTS OF CULTURAL TREATMENTS ON YIELDS OF CORN FOLLOWING WINTER COVER CROPS

Tillage method	Cover Crop	Avg. yield (1943-49) bu/acre
Mulch, balk method	vetch and rye	50
Mulch, disk method*	vetch and rye	50
Plowed, clean cultivation	vetch and rye	49
Mulch, balk method	crimson clover	46
Mulch, disk method*	crimson clover	49
Plowed, clean cultivation	crimson clover	49
Plowed, clean cultivation	none	46

* Graham-Hoeme implement used after disking in 1949

So far as the Southeast is concerned, this was pioneer work. In other sections, notably Nebraska, machinery had been developed for mulch farming. Wide, flat sweeps equipped with rolling coulters predominated for the plowing operation. Equipment of this kind was available from several sources and in the preliminary studies much of it was tested for the Piedmont conditions previously described. Without exception all equipment of this type has been ruled out as unsatisfactory. In hard, dry soil, penetration is a problem and the presence of rocks resulted in twisted and broken sweeps and failure of other machine parts.

Three tillage methods for corn production involving the use of winter cover crops as sources of mulch have been compared; namely, mulch balk, mulch disk, and plowed, clean cultivation. Data on yield, runoff, and erosion are summarized in Table 1 and Fig. 1 for the period 1943-49. Plant residue maintained as a mulch was very effective during this period in reducing runoff and erosion and the yields were not depressed over conventional methods.

Machines and techniques of production have varied during this period. For example, a variety of hybrid corn was substituted for an open-pollinated variety. Space will not permit a full description of the various machines and attachments which have been tested; therefore, only those items which have proven satisfactory will be described.

A heavy-duty tandem-disk harrow equipped with scalloped disks and weight boxes is used for the first operation in killing the cover crop of vetch and rye mixed or crimson clover (Fig. 2). The setting of the disk, weight, and speed of operation varies with soil-moisture conditions. The objective is to kill as much of the vegetation as possible without incorporating it with the soil. This operation is usually done the first week in April. About two weeks later, the second operation of opening up planting furrows is completed. Equipment consists of a modified middlebuster, as shown in Fig. 3. Moldboards are removed, the frog is cut down to allow soil to fall back in the furrow, disk hillers are attached and adjusted to move the vegetation away from the furrow and a rolling coulter cuts through the material and prevents clogging. This operation is carried out for all treatments. In 1949, a Graham-Hoeme plow (Fig. 4) preceded the above operation in the mulch-disk treatment for loosening up the soil. The latter implement was developed in the Southwest, but the smaller sizes are adapted and readily accepted in the Southeast. The third treatment, consisting of turning under the cover crop, followed by clean cultivation, employs the use of a disk plow and disk harrow.

A conventional planter with a fertilizer attachment is rigged to plant in the furrows developed by the middlebuster attachment (Fig. 5). Disk hillers are employed to push vegetation out of the furrow so it will not interfere with the planting.

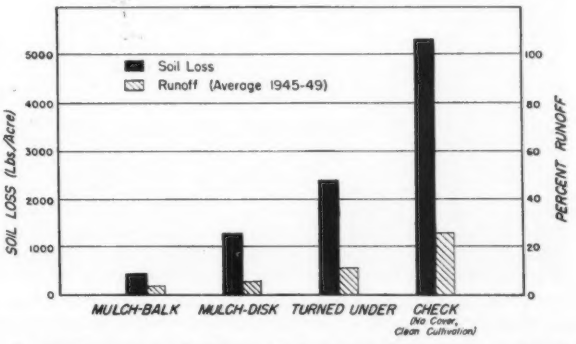

Fig. 1 Comparison of tillage methods on the effectiveness of vetch and rye for reducing runoff and erosion

Planting should follow the operation of opening furrows as soon as possible; otherwise the soil in the furrow will dry out and become cloddy.

A rotary hoe is used for the first and occasionally for the second cultivation. By this time the corn should be big enough for the use of sweeps. Small sweeps are used on the front of the cultivator and staggered to prevent clogging or to reduce it to a minimum. Large sweeps may be used on the rear rig. The same combination of sweeps may be used a second time, which is usually the lay-by operation. A side dressing of nitrogen is usually applied at this time.

Planting, application of fertilizer and cultivation is uniform for all treatments involving the use of a cover crop. The furrowing operation is eliminated in the check.

Although the technique and equipment described above is satisfactory and practical in the hands of farmers, the opportunity to improve existing machinery is obvious. The operation of developing furrows should be eliminated as a separate one and combined with planting. This has been done experimentally, but existing planters used in the Southeast are not strong enough to open the furrows to the required depth, and power is a limiting factor in the small tractors. Dry, cloddy soil produces a very poor seedbed, and this is the condition following planting unless optimum moisture conditions prevail. This is not limited to the mulch system. It is characteristic of clay-type soils which are low in organic matter. The clean tillage practice permits the reduction of clod sizes by repeated disking and harrowing. Perhaps a pulverizing attachment for the planter is an answer to the problem.

Summer cover crops such as annual lespedeza and crotalaria may be used as sources of mulch for corn. The problems of dealing with a live crop and the usual insect problem which often appears where winter legumes are grown are eliminated. Equipment and techniques described in preceding paragraphs worked equally well or better in the dead residue of summer cover crops.

The use of mulches in cotton is also being investigated, but yields have been reduced. Several factors are responsible. Cotton is planted on ridges and it is difficult to obtain these ridges or beds and have enough mulch left between beds to be effective. In contrast to corn, weeds and grasses must be eliminated in cotton to facilitate harvesting. A third factor is the presence of plant residue which provides a harboring place for boll weevils. A practical solution to these problems has not been worked out.

Small grain is occupying much of the acreage that was formerly planted to cotton. These crops are usually planted in the fall and do not provide much cover and protection during the late fall and winter months. Therefore, turning of the soil is no longer a prescribed operation for preparing grain land. Disk harrows, which incorporate some plant residue but leave much of it on or near the surface, are being used. Field tillers are being used ahead of the disking operation (Fig. 4). Although many farmers are not cognizant of the fact that they are following a system of mulch farming, such is the case where disk harrows and tillers are used for preparing grain land. In tests conducted at Clemson, soil and runoff losses have been reduced to negligible quantities and yields have been significantly higher when the combination of field tiller and disk harrow was used for preparing a seedbed for grain.

Combining the factors of high annual rainfall, intensity of rains, rolling topography and erodible soils, the Southeast is one of the most vulnerable areas of the United States to soil erosion. A tremendous amount of damage has already been done in this area. The factors listed cannot be altered but farming practices may be modified to reduce erosion. The utilization of plant residue in the form of mulch offers a practical solution where intensive row-crop farming must be practiced. Techniques have been worked out for the production of corn and small grain where mulch is utilized. Although existing machinery has been adapted and modified for this system of farming, additional machines and improvements are needed. Row-crow planters should be given first consideration. Soil-preparation tools and cultivators should be developed for this use also.

In recent years, the sale of farm machinery in the Southeast has exceeded the most optimistic estimate of manufacturers. Some of this machinery was developed for the peculiar conditions of the area, some was imported with satisfactory results from other areas, but a lot of it does not meet the requirements of the region and is a poor investment to the farmer. As competition becomes a more important factor, machinery will be purchased on the basis of its merits. Manufacturers should give increasing consideration to the needs of this area through their product development programs, and mulch machinery should be included in this program.

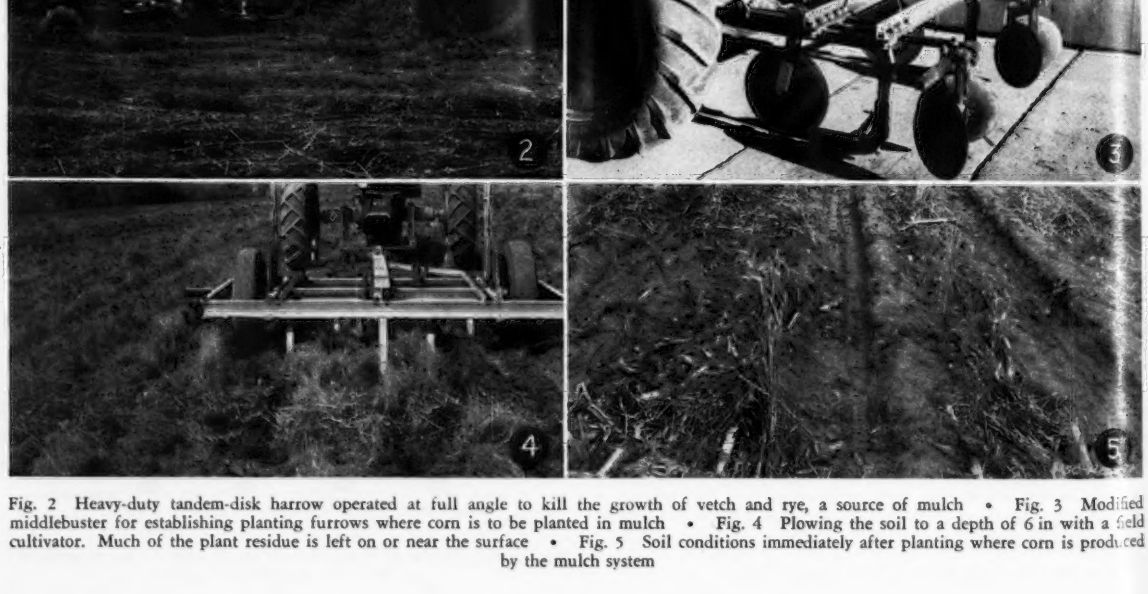

Fig. 2 Heavy-duty tandem-disk harrow operated at full angle to kill the growth of vetch and rye, a source of mulch • Fig. 3 Modified middlebuster for establishing planting furrows where corn is to be planted in mulch • Fig. 4 Plowing the soil to a depth of 6 in with a field cultivator. Much of the plant residue is left on or near the surface • Fig. 5 Soil conditions immediately after planting where corn is produced by the mulch system

Machinery Problems in Mulch Farming

By L. L. Harrold and F. R. Dreibelbis
MEMBER A.S.A.E.

THE spread of interest in mulches for row crops over the past decade has been phenomenal. A majority of the agricultural experiment stations are now engaged in some research work along this line. It is appropriate that we in research work pause long enough to orient ourselves, summarize our findings to date, and reset our sights on research for the future. This paper will present results from some of the work in Ohio over the past 8 yr. The U. S. Soil Conservation Service (Research) and the Ohio Agricultural Experiment Station are attacking the problem on a cooperative basis.

Simultaneous with infiltration work in other states about 10 yr ago, rainfall applicators were put to use in Ohio for the determination of infiltration rates into soils. Borst and Woodburn(1)* carried on such activities at the Soil Conservation Service Zanesville Experiment Station in 1940. They found that bare soil (Muskingum silt loam) sealed quickly under the impact of raindrops. The ability of this soil to absorb rain water almost stopped as this process continued. Runoff and erosion were excessive. The effect of a mulch on the ground surface or even supported one inch above the ground produced amazing results. As compared with the unprotected sealed soil, the mulch maintained an open surface and reduced runoff 75 per cent. Erosion was cut down from 10 tons per acre to only a trace.

The mulch used in this experiment was straw, applied at a rate of 2 tons per acre, placed on the plot before a 2-in rainfall application. This and other similar experiments revealed the possibility of (a) further reducing soil losses and getting more control of water than has been possible with those land-use practices now being recommended and (b) getting conservation on land which was not adaptable to contouring.

Consequently we set to work planning a series of field experiments using crop residues for mulch on cornland. At that time (1943) twelve 18 x 35-ft plots were laid out on a slope of 20 per cent for the mulch experiment. The soil was a moderately deep, well-drained Muskingum silt loam over sandstone or shale. The vegetation was a 2-yr alfalfa—timothy sod. Six plots were plowed with the moldboard plow. The sod on the other six plots was cut with a tandem orchard disk heavily weighted and pulled with a track-type tractor. By lapping half way the sod was thoroughly cut up and mixed to a depth of about 7 in. Plowing and disking operations were carried on the same day.

The results—soil splash, soil moisture, soil structure, and crop yield—looked so good that the plot plan was extended to a 4-yr rotation of corn-wheat-meadow-meadow. Also plans were made to study these operations on a field watershed of 2 acres. Here runoff and erosion could be measured under natural conditions. These observations were also very encouraging.

We were not satisfied with the kill on the sod obtained with this disk. Also, more power was required to pull it than is available on the average farm. Next we tried a single cutaway-edge disk carrying a 600-lb weight. This was pulled by a standard 2-plow tractor. It cut up the sod fairly well, but did not completely cut it loose. Next, we removed the moldboards from a 2-bottom plow and tried it in sod. It cut the sod loose, but the long ribbons of sod were difficult to handle in subsequent fitting and cultivating operations.

On some areas where the disk did not kill all the old vegetation, a herbicide (2,4-D) was used. Pre-emergence applications were effective in killing many weeds and temporarily stunting the growth of grasses. First cultivation was omitted. Subsequent cultivation was necessary to control grass and weeds.

At Wooster, Ohio, a field cultivator was used on the sod but it failed to kill enough of the vegetation. Another scheme was tried—plowing the sod with a moldboard plow and following two weeks later with a field cultivator. Thus some organic residues were brought up to the surface for a mulch. This practice appeared to have some promise of success.

Along with a discussion of general observations of mulch experiments, it is desirable to consider some of the technical findings. These tend to emphasize the importance of mulch culture and to direct future research on the problem.

Runoff and Erosion. Watershed observations made in 1944 revealed that the mulch surface did not seal. Only once during the entire summer did this area yield significant runoff. Data in Table 1 show the effectiveness of this mulch.

TABLE 1. RUNOFF AND SOIL LOSS ON PLOWED AND MULCH WATERSHEDS, COSHOCTON, OHIO, MAY-SEPTEMBER, 1944

Treatment	Rainfall, in	Runoff, in	Soil loss, tons/acre
Plowed	14.70	2.74	25.00
Disked	14.70	0.82	0.27

Soil Splash. Splash of soil caused by raindrops on the plowed and mulch plots was measured in 1944 and 1948 (Table 2). Shallow tin cans were used for this purpose.

TABLE 2. AMOUNT OF SOIL SPLASHED BY RAIN DROPS, PLOWED AND MULCH PLOTS, 1944 AND 1948

	Soil splash, tons/acre	
Treatment	1944	1948
Plowed	13.6	11.8
Mulch	7.6	7.4

Soil Moisture. Soil moisture was measured periodically throughout the growing season by field sampling and by taking the electrical resistance of calibrated gypsum blocks. Data for 1948 (Table 3) are typical of the results to date.

TABLE 3. SOIL MOISTURE IN PLOWED AND MULCH PLOTS, 1948†

Date	Moisture (per cent by volume) in depth of —							
	0-1 in		1-4 in		4-7 in		7-10 in	
	Plowed	Mulch	Plowed	Mulch	Plowed	Mulch	Plowed	Mulch
June 26	25.6	27.4	26.4	27.6	26.0	27.1	26.9	28.4
July 8	16.2	19.6	16.1	20.5	17.3	21.9	23.8	25.9
July 21	12.2	15.8	12.9	15.3	13.0	16.5	19.8	21.7
Aug. 4	10.1	14.2	11.6	14.4	11.9	15.8	18.7	21.4
Aug. 30	5.1	5.9	6.4	7.2	6.9	7.8	11.6	12.6

† More detailed information given in reference (2).

Soil Structure. The effect of mulch on the structure of the soil at successive stages of a corn-wheat-meadow-meadow rotation is illustrated by data in Table 4. Mulch and plowing are compared on the basis of quantity of plant residues, air space porosity, and volume of total aggregates for each of the 4 yr following the initial tillage. The only difference between the mulch and plowed-plot operations in 4 yr occurred in the first tillage of the corn year.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1949, as a contribution of the Soil and Water Division.

The authors: L. L. HARROLD and F. R. DREIBELBIS, project supervisor and soil scientist, respectively, North Appalachian Experimental Watershed, Soil Conservation Service (Research), USDA, Coshocton, Ohio.

* Numbers in parentheses refer to the appended references.

TABLE 4. SUMMARY OF SOIL CHARACTERISTICS ON MULCH PLOTS FOR ONE COMPLETE ROTATION(2)

Determinations	Depth, in	First year corn*		Second year wheat†		Third year meadow‡		Fourth year meadow§	
		Plowed	Mulch	Plowed	Mulch	Plowed	Mulch	Plowed	Mulch
Plant residues,	0 - 1	234	734	422	957	765	984	1452	1763
lbs per acre-inch	1 - 4	152	952	432	717	351	565	417	495
	4 - 7	261	216	389	196	217	98	274	228
Air space porosity,	0 - 1	23.1	24.1	20.3	20.7	15.0	13.1	14.9	19.3
per cent of volume	1 - 4	22.1	23.7	14.3	17.4	14.7	15.5	16.8	17.7
	4 - 7	19.1	19.0	13.9	12.9	15.2	14.8	19.7	16.7
Total aggregates‖	0 - 1	33.2	40.9	35.8	46.0	37.8	48.4	34.0	49.2
8 to 0.2 mm (per cent)	1 - 4	36.6	41.3	36.6	41.2	38.5	46.6	35.5	45.0
	4 - 7	37.1	38.4	39.2	38.0	43.9	40.3	33.6	37.5

* Corn, 1946—sampled October 14, 1946.
† Corn, 1945; wheat, 1946—sampled July 24, 1946.
‡ Corn, 1944; wheat, 1945; meadow, 1946—sampled August 7, 1946.
§ Corn, 1943; wheat, 1944; meadow, 1945-1946—sampled June 24, 1946.
‖ All samples for aggregate analysis taken September 27, 1946.

Crop Yields. Corn yields (Table 5) were taken from the mulch plots.

TABLE 5. CORN YIELDS ON MULCH PLOT EXPERIMENT 1943-48

Year	Yield, bu per acre		Remarks
	Plowed	Mulch	
1943	102	106	
1944	92	97	
1945	77	65	Crow damage on mulch plots necessitated replanting
1946	84	90	
1947	88	90	
1948	67	55	Poor sod preceding corn; nitrogen deficiency in August

Corn yields on mulch-culture plots at Wooster and Columbus, Ohio(3), have in general been less than on plowed plots. These soils are less permeable than the Muskingum silt loam at Coshocton. Wherever a straw mulch was applied on the sod after it was plowed, however, the corn yields were not depressed.

PROBLEMS FOR SOLUTION

Listed below are some of the problems involved in mulch culture. They are not in order of importance. None of them have been solved completely.

1 How much mulch do we need? If the sod is cut roughly in the fall, there is little left for mulch. If the sod is allowed to grow much in the spring, there may be too much organic matter. The presence or absence of legumes will make some difference.

2 Where should the mulch be? Sod residues will be mixed in different amounts into the soil by tillage operations. Should it be a shallow or deep mixture? Straw may not be mixed in at all. These differences will have a varying effect on the aggregation and soil structure of the ground surface.

3 How deep should the organic residues be mixed? Some tools will not mix deep. Others will place the residues deep and leave practically none in the surface soils. Still others will mix evenly to a depth of 7 in. Plowing operations have for decades placed organic matter below the surface to a depth of 7 in. Permeability of this horizon is usually high. With only little organic matter below this depth, the permeability is extremely small. Will mulch culture tend to keep more organic matter nearer the surface, thus reducing its content below, say, 4 in? If so, then high permeability will prevail to less depth. Consequently less of the soil profile can be used for water storage during storms. In other words, will mulch culture tend to develop a shallower topsoil?

4 Should we assume that the mulch for corn is to be supplied exclusively from the sod preceding corn, or is it practical to consider spreading a mulch on the land after seeding? Some of our best yields have been obtained in the latter way.

5 What is the desired depth of planting in a mulch seedbed?

6 How does a loose mulch seedbed affect germination and stand of corn? Our data show poorer stands of corn on mulch plots.

7 How does cultivation and use of chemical weed control fit into a mulch program? Many stands of corn on mulch corn-land have been harmed by the first cultivation. Great care must be exercised to keep this damage small. Perhaps this cultivation can be eliminated by the use of herbicides.

8 Will the physical properties of the soil be changed materially over a long period of time by use of mulch culture? Will this be beneficial or detrimental?

9 Is the soil profile drainage a factor to be considered in the use of mulch culture? Poorly drained soils should not be kept wet too long. No mulch in the early summer wet period and a mulch in the dry later summer might work. Is this practical?

Perhaps we can direct and coordinate our research more along the lines of developing answers to these questions. Machinery problems are closely tied into each one.

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LETTER TO THE EDITOR

Sees Need of Wise Policy

TO THE EDITOR:

IT IS quite important at this time that more than superficial consideration be given to determining a wise policy for the American Society of Agricultural Engineers that may guide its officials, if it is to lead the profession to a position of maximum opportunity and service in the important field of soil and water conservation.

It is significant that a very high percentage of the agricultural engineers now engaged in soil and water work are in supervisory positions over staffs including subject-matter specialists in other lines, e.g., soil scientists, crops and forestry specialists, civil engineers, etc. As I have stated publicly before, I know of no basic training and experience better than that afforded an agricultural engineer as qualification for planning and supervision of a work which so inseparably combines the development and application of the biological and physical sciences as they are combined in soil and water management. The ascendency of agricultural engineers to positions of general leadership in this field is, of course, a genuine asset to the profession and one that can be increased materially through the placement of more agricultural engineers in staff positions where they can work hand-in-hand with specialists in other subject-matter lines and can thereby greatly enhance their vision of the entire problem.

An isolation of agricultural engineers in soil and water work from needed close collaboration with other scientists engaged in the same work and the resultant reduction of their opportunity for advancement to positions of general leadership in the field would be a most unfortunate blow to advancement of the agricultural engineering profession, as well as a very real handicap to the progress of the nation in conservation of its most basic resources.

R. B. HICKOK

Lafayette, Ind.

Application of the Double-Cut Plow Principle to Mulch Tillage

By J. H. Lillard, J. E. Moody, and T. W. Edminster
MEMBER A.S.A.E. JUNIOR MEMBER A.S.A.E.

THE topography of most of Virginia's cultivated land ranges from rolling to steep. Except for certain special crops, agriculture is developed generally around rotations having one year of open cultivated crop, one year of small grain and one or more years of forage crops. Research (4 *) has shown that more than 90 per cent of the erosion losses during such a rotation occur during the growing period of the open cultivated crop. Contour strip farming and other appropriate soil-conservation practices are constantly reducing these losses. Tests(4) have shown, however, that even with the best of these practices, serious soil movement continues to take place within the strip width. The natural conclusion is that improved tillage practices are needed.

Greater utilization of crop residues for mulches seemed the most logical approach toward the development of more effective methods of cultivation for soil and water conservation. The effectiveness of mulches in dissipating the energy of falling raindrops and in maintaining the soil in an absorptive condition is well established.(1, 2, 5). However, many problems are involved in the development and application of mulch tillage practices which may not be so well understood. Among the more important of these are the machinery requirements which always are closely interrelated with climatic, crop, and soil conditions. As a result, the mechanical processes necessary for the successful utilization of crop residues as mulches will vary widely in different sections of the country.

This report briefly summarizes results from the mulch-tillage investigations in Virginia during the past six years and points out those problems upon which further experimentation is required.

The first study in Virginia dealing with the use of vegetative residues for mulches was begun in 1944. The principal objective was to test the effectiveness of such tools as sweeps, moldboardless plows and disks in producing an effective residual vegetal mulch and to determine the effect of such treatments on crop yield. A recommended 3-yr rotation of corn, wheat, and clover was used. The special tillage treatments were used in preparation of the corn seedbed only. All other tillage was standard for this area and uniform over all the plots.

The results of these early studies have been reported previously in AGRICULTURAL ENGINEERING(3). As indicated in that report, the excessive yield depressions obtained with each of the practices precluded their successful application under Virginia climatic, crop and soil conditions. But even more important, these results gave rather definite clues to certain major problems that must be overcome in order for the mulch tillage practice to succeed. Regrowth of the perennial grasses and legumes which are always present preceding the corn crop must be eliminated and weed growth controlled. Plant nutrients must be available in sufficient amounts throughout the growing season. Conditions favorable to good seed germination must be provided.

The Double-Cut Plow. On the basis of this knowledge, a new carefully designed experiment was initiated using as the basic tillage tool a commercially available double-cut plow (Fig. 1), followed by either disking or spring-tooth harrowing or combinations of both. When used as a mulching tool, the double-cut plow is adjusted so that it completely inverts the top 3-in sod layer and simultaneously subtills an additional 4 in, giving a total tillage depth of 7 in (Fig. 2). This operation is performed as early in the spring as weather permits, usually in March. Seedbed preparation is delayed until near seeding time. It has been found that 30 to 45 days exposure of the sod roots in this manner effectively kills the perennial grasses and legumes. Then, in preparing the seedbed, about one-half the dead vegetal residues can be brought back to the surface with a standard spring-tooth harrow (Fig. 3). As a result, about one-half of the mulch is distributed over the surface and the remainder within the top 3 in of the soil, thereby affording excellent soil and water conservation. Also the surface collection of viable weed seed is placed 3 in under the surface where the corn grain has a little better than even chance of germinating before the weeds offer too much competition.

Several combinations of the spring-tooth harrow and disk have been used in seedbed preparation in an effort to determine the best condition for soil and water conservation and also for seed germination and plant growth. Unfortunately the most effective tillage for the optimum condition in each case appears to be somewhat different. Therefore, it has been necessary to investigate several modifications of existing planting methods in a further effort to achieve effective germination and plant growth without sacrificing soil and water conservation effectiveness.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1949, as a contribution of the Soil and Water division, and is a joint contribution of the agricultural engineering department, Virginia Agricultural Experiment Station, and the Soil Conservation Service (Research), U. S. Department of Agriculture.

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* Numbers in parentheses refer to the appended references.

Fig. 1 (*Left*) The Oliver TNT plow in use as the basic tillage tool in the double-cut plow mulching method • Fig. 2 (*Center*) A view of the furrow following the double-cut plow. The 3-in sod layer is completely inverted, and the 3 to 7-in layer thoroughly tilled by the bottom share • Fig. 3 (*Right*) A view of the mulched seedbed prepared with the double-cut plow and spring-tooth harrow

Fertilization methods have been varied in an effort to determine which methods provide the best distribution of available nutrients throughout the growing season.

The 1947 Studies. The double-cut plow method of mulching was used first in 1947. In a generalized field experiment it proved greatly superior to all of the sweeps, rippers and disks used in the earlier studies, but still did not give stands and yields quite comparable to those obtained with the turn plow.

An analysis of these results supported by careful field observations and limited soil and plant tissue analyses throughout the growing season leads to the belief that the 10 to 15 per cent yield and stand depressions experienced following tillage with the double-cut plow are susceptible to elimination with further research.

The 1948 Studies. Closely controlled studies in 1948 were designed to give special emphasis to the stand and yield problems. As would be expected, the seedbed prepared with the spring-tooth harrow following tillage with the double-cut plow is extremely loose, with high concentrations of dead vegetative material in the top 3 in. When seeding under such conditions with the conventional runner openers, corn grains are often placed on clumps of vegetative material without sufficient contact with the soil to promote good germination. Other toxic conditions as a result of the excess mulch in the row may be present also.

Random soil and plant tissue analyses in the earlier studies showed a marked difference in available plant food throughout the growing season. In many cases, nutrient starvation signs could be observed on the growing plants. There were also indications of differences in the plant's ability to assimilate the nutrients under the various tillage treatments.

The various treatments used, together with a summary of the results obtained in 1948, are given in Table 1. During the

TABLE 1. SUMMARY OF 1948 RESULTS FROM MULCH TILLAGE EXPERIMENTS AT BLACKSBURG, VA.

Item	Values				No. samples in comparison	Significance of differences by analysis of variance
Tillage Treatments*	1	2				
Yield in bu/acre	90.0	108.8			36	0.01
Stand in per cent	81.7	90.5			36	0.01
Fertilizer Treatments†	1	2	3			
Yield in bu/acre	97.3	97.2	103.6		24	None
Stand in per cent	83.9	92.1	82.4		24	0.01
Corn Planter Modification‡	1	2	3	4		
Yield in bu/acre	103.0	102.3	97.9	94.2	18	<0.05
Stand in per cent	84.8	88.3	85.3	86.1	18	None

* Tillage treatment: (1) double-cut plow plus two spring-tooth harrowings, (2) turn plow plus two diskings

† Fertilizer treatment: (1) 500 lb/acre down at seeding; (2) 500 lb/acre down at seeding plus 80 lb/acre of nitrogen before 1st cultivation; (3) 500 lb/acre down at seeding plus 80 lb/acre of nitrogen before last cultivation

‡ Planter modification: (1) conventional runner opener with treader wheels in front and press wheels in rear; (2) same without the rear press wheels; (3) conventional runner opener; (4) conventional runner opener with rear press wheels

period from April through September, there was a total of 26.7 in of rainfall exceptionally well distributed. Although all yields are high as a result of the very favorable season, there was a highly significant tillage effect. Likewise, there was a similarly high significant difference in the per cent stand.

The application of nitrogen side dressings in addition to the basic application of 500 lb/per acre of 4-12-4 fertilizer at seeding showed no significant effect on yield either when applied before the first or last cultivation. However, the nitrogen application before the first cultivation significantly increased the stand. This result is not fully understood but is believed to be due mainly to a beneficial effect on the survival of the weaker stalks. There was no evidence of a significant interaction of fertilizer and tillage.

The various corn planter modifications listed in Table 1 failed to show a significant effect on either the corn stand or the yield. However, there is a rather definite trend of increased yields with planter modifications 1 and 2 which provided more compaction in the corn row.

Supporting laboratory experiments during the 1948 season showed the following results: The various plant-food deficiencies which were evident in the earlier mulch studies, where sweeps, disks and rippers were used, were not present to nearly as great an extent, following use of the modified implements. These data indicate, however, that under conditions prevailing in 1948 there still remained important problems of nutrient assimilation by corn plants grown on mulch-tilled areas. These problems existed despite the fact that there were no visible signs of any nutrient deficiencies at any time during the growing season.

Periodic determinations of NO_3-N, soluble P, and soluble K in the leaf tissue through the growing season revealed a significantly lower content of each in the mulch-tilled corn. The addition of the nitrate of soda increased the average amount of NO_3-N in the leaf tissue in both the mulch and check areas but had no effect on the pickup of P and K.

Likewise, the total nitrogen content of the corn plant (all growth above ground including ears) was significantly lower on the mulch-tilled corn. Again the addition of the nitrate of soda as side dressing increased the total nitrogen content of the corn plant on the mulch-tilled and check areas.

Analysis of the corn grain gave no significant difference in the total nitrogen content as a result of tillage. There was, however, a highly significant increase in nitrogen as a result of the nitrate of soda side-dressings on all plots. Since the nitrogen content can be converted to a measure of protein, it is evident that this important factor was not affected by use of the double-cut plow tillage method.

While the NO_3-nitrogen content of the 0-6-in layer of soil in the tillage plots varied enormously throughout the season as a result of the various fertilizer treatments, biological activity, and plant pickup, the season average was not affected significantly by tillage. Again the nitrate of soda side-dressing treatments increased the seasonal average supply of NO_3-nitrogen on all plots.

The 1949 Studies. A new study retaining the double-cut plow as the basic tillage tool but including variations in seedbed preparation, fertilizing methods and a different corn-planter modification, was undertaken. These various treatments together with the 1949 yield and stand data are summarized in Table 2.

It is evident from inspection of these data that the yields were little more than half those of the preceding year. Likewise, the corn stand was exceptionally poor. Unfavorable climatic conditions, particularly the poor distribution of rainfall during the early growing season, are believed mainly responsible for the low stands and yields. All of the plots were located on contour strips adjacent to the 1948 studies. The soil is inherently rich in all of the major nutrients.

It is interesting to note that under the 1949 conditions there were no significant differences in either the corn yield or the percent stand as a result of tillage. Furthermore, there was no significant response from any of the fertilization practices on any of the plots or any evidence of interaction between tillage and fertilizer treatments. This latter result is undoubtedly due to the highly unfavorable 1949 growing conditions and hence would not be expected in a more normal year.

Both per cent stand and yields were increased to a highly significant degree as a result of planter modification No. 2. This modification was designed to remove the vegetal mulch from the row and to provide better compaction of the seedbed. Experience to date indicates that both of these effects are necessary for improved germination under mulch conditions. It was not expected, however, that this planter modification would interact with tillage to exert its greatest influence on the check or clean-tilled plots as the analyses show it to do.

All of the mulch treatments (tillage treatments No. 1, 2 and 3) provided conditions highly satisfactory for effective

TABLE 2 SUMMARY OF 1949 RESULTS FROM MULCH TILLAGE EXPERIMENTS AT BLACKSBURG, VA.

Item	Values				No. samples in comparison	Significance of differences by analysis of variance
Tillage Treatments*	1	2	3	4		
Yield in bu/acre	52.4	50.4	55.8	53.6	32	None
Stand in per cent	58.9	59.1	60.6	59.1	32	None
Fertilizer Treatments†	1	2	3	4		
Yield in bu/acre	58.5	49.0	53.9	50.6	32	None
Stand in per cent	60.7	58.0	58.3	60.7	32	None
Corn Planter Modification‡	1	2				
Yield in bu/acre	45.5	60.8			64	0.01
Stand in per cent	52.2	66.7			64	0.01
Planter Modification and Tillage	1	2	3	4		
Mod. 2 — Mod. 1 in bu/acre	13.3	11.8	10.7	26.3	32	0.05
Mod. 2 — Mod. 1 in per cent stand	13.0	10.0	11.6	23.9	32	0.05

* Tillage treatment: (1) double-cut plow—3-in top 4-in bottom plus twice over with spring-tooth harrow; (2) double-cut plow — 3-in top 4-in bottom plus one disking followed by one spring-tooth harrowing; (3) double-cut plow — 3-in top 4-in bottom plus one spring-tooth harrowing followed by one disking; (4) conventional turn plow — 7-in depth plus two diskings

† Fertilizer treatment: (1) 1000 lb/acre 10-6-2 fertilizer broadcast in furrow beneath 3-in sod layer during the plowing operation; (2) 300 lb/acre 4-12-4 fertilizer broadcast over surface at seeding; 200 lb/acre 4-12-4 fertilizer sown with planter at seeding; 500 lb/acre 16-0-0 fertilizer applied as side-dressing when corn was approximately 18 in tall; (3) 500 lb/acre 16-0-0 fertilizer broadcast in furrow beneath 3-in sod layer during the plowing operation; 300 lb/acre 4-12-4 fertilizer broadcast over surface at seeding; 200-lb/acre 4-12-4 fertilizer sown with planter at seeding; (4) None

‡ Planter modification (1) standard two-row planter with runner openers; (2) Same with rolling coulter in front of runner, double-disk furrowing attachment, and wheel bands

soil and water conservation. Little difference could be noted between them except for a slightly more even distribution of the vegetal mulch where the disk preceded the spring-tooth harrow. Also in treatment No. 3, when the disk followed the spring-tooth harrow, the seedbed was slightly more compact with somewhat less mulch on the surface.

From results of the soil and plant analyses throughout the 1949 season, it is evident that tillage had no significant effect on the plant-food content of the corn plant or grain under the 1949 conditions. The effect of the four different fertilizer treatments failed to show the differences which would be expected in a more normal season.

Summary. This report traces the progress of the major studies on machinery problems involved in utilizing crop residues for mulches in Virginia. While many problems, particularly those concerned with nutrient relationships and seed germination, have not been completely solved, much progress has been made.

It has been definitely shown that in farming systems having rotations which include one or more perennial grass and legume crops subsurface tillage with sweeps, rippers, etc., is totally unsuited. When such tillage practices are followed by repeated diskings the vegetative regrowth is so swift and dense that the planted crop cannot successfully compete for food and moisture.

This condition led to development of the double-cut plow principle of mulch tillage. This method successfully overcomes the regrowth problems without materially sacrificing soil and water conservation effectiveness. The yield and stand depressions obtained with previous mulching practices are greatly reduced by this method. In fact, they are reduced to the extent that experimentation over a longer period of time and a wide range of climatic and soil conditions is necessary to determine with certainty whether or not any real differences prevail.

Effective methods for overcoming the indicated differences in nutrient assimilation by the plants throughout the season requires further investigation. It is not expected that any change will have to be made in the double-cut plow operation to solve these problems.

Further experimentation is necessary to devise the most effective methods of seedbed preparation following initial tillage with the double-cut plow. Results to date indicate that approximately half of the vegetative residue should be returned to the surface, but this value has not been precisely established. Other factors of mulch distribution and soil compaction require further study.

It is evident from the results obtained in 1949 that germination efficiency can be materially increased through improved planting methods. Special emphasis will be given this problem in subsequent studies.

Despite the fact that experiments to date have failed to show significant difference in yields as a result of different fertilizer practices, there is positive evidence from the laboratory analyses that there is a definite difference in plant food availability in the soil throughout the season as a result of the mulching treatments even though there is only slight difference in the season average. Careful investigation of this condition will be continued and expanded to include studies of possible soil microbiological factors.

CONCLUSIONS

Results of research over the last six years indicate rather definitely the general type of machines necessary to effectively utilize crop residues for mulches under Virginia conditions.

1 The double-cut plow for the basic tillage treatment followed by an appropriate combination of the spring-tooth harrow and disk for returning the mulch to the surface and preparing seedbed, constitute the required tillage tools.

2 Corn planting equipment requirements for maximum seed germination have not been definitely established but it seems highly improbable that any new types of equipment will be required.

3 Standard commercially available cultivators operate satisfactorily following the double-cut plow method of mulching.

4 Fertilizer placement equipment requirements have not been definitely established, but research to date indicates that no new types of equipment will be required.

5 Further experimentation under a wider range of crop and soil conditions is necessary to evaluate possible residual effects of the mulch treatments and effects of yearly variations in climate.

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Responsibilities of Knowledge

ANY widening of the borders of our knowledge imposes an increased responsibility on individuals and nations through the possibilities it gives for shaping the conditions of human life. The forceful admonition in this respect which we have received in our time cannot be left unheeded and should hardly fail in resulting in common understanding of the seriousness of the challenge with which our whole civilization is faced. It is just on this background that quite unique opportunities exist today for furthering cooperation between nations on the progress of human culture in all its aspects.—*From "An Open Letter to the United Nations," by Niels Bohr, in Science, July 7, 1950.*

Some Results of Mulch Tillage for Corn

By E. R. Baugh, R. B. Hickok, H. Kohnke, and I. D. Mayer
MEMBER A.S.A.E. MEMBER A.S.A.E.

CROP residues used as a mulch are effective in conserving moisture and controlling erosion. They protect the soil surface from the beating action of the rain and retard surface flow. When the residues are plowed under, little undecomposed organic matter remains at the soil surface to protect it from these erosive forces.

Many research workers have noted a reduction in yield when a mulch is used. This reduction seems to be very closely related to the fertility level and to the decomposition of the residues. Certain essential elements are required for both plant growth and the organisms decomposing the residues. When the growing plant and the organisms decaying the residues compete for an elment, there is a decrease in crop yield.

The residues from meadow and small grains have been used as mulching materials. Since in common practice meadow is followed by corn in the rotation, meadow residues are being used as a mulch for corn in the current experiments. When meadow residues are used, problems of preparing the seedbed, planting, and cultivation are different from the problems encountered where small grain residues are used. However, the primary objectives are the same: the reduction of erosion and conservation of water without seriously reducing the yield of the crop being grown. In Indiana, erosion by water is serious; yet the conservation of water is important for maximum crop yields.

Review and Discussion of Literature. One of the factors listed by R. E. Yoder(1)* as necessary for a good soil management program is sufficient depth of arable soil. Since on gently rolling to steep slopes erosion may quickly reduce the depth of arable soil, water control is necessary if crop yields are to be sustained.

With sufficient depth of arable soil and at higher levels of fertility, the amount of water available to the crop becomes important. R. B. Hickok(2) et al conclude that with favorable soil conditions one inch of water saved during the growing season of corn increased corn yields 6 bu. per acre.

Water to be used by a growing crop has to enter the soil and become a part of the soil water. F. L. Duley's(3) work with mulches shows that they are effective in preventing the formation of a thin compact layer through which water penetrates slowly. When the compact layer is present, it decreases infiltration and increases runoff and erosion during the storm period.

After a rain, evaporation decreases the amount of water that can be used by the growing crop. J. C. Russell's(4) experimental work shows that four tons of straw reduced evaporation from early forenoon to late afternoon 73 per cent compared with soil open to the sun and wind. On the same basis, 1½ in of air dry soil reduced evaporation 91 per cent during the same period of time. After four days there was no difference in evaporation between the straw-mulched and the soil-mulched areas. Two tons of straw per acre were almost as effective as eight tons per acre.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1949, as a contribution of the Soil and Water Division. It has been approved as Journal paper No. 461, Purdue University Agricultural Experiment Station, and is a report of a cooperative soil and moisture conservation investigation by the Purdue station and the Soil Conservation Service, (Research), USDA.

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AUTHOR'S NOTE: The authors wish to acknowledge numerous helpful suggestions by N. L. Stoltenberg in preparing this paper.

* Numbers in parentheses refer to the appended references.

Some Prior Mulch Studies in Indiana. The experimental use of mulches on field crops for erosion control was started in 1939 at Purdue University when straw was used as a mulch on wheat. The first few experiments utilized mulches that were transported to the field and applied after the crop was planted. In the fall of 1941, a preliminary study which used crop residue grown in place as a mulch (residues of the preceding crop) was initiated and the first implement used was the one-way disk plow. In the spring of 1942, flat V-shaped steel cutters (called sweeps) and the moldboard plow with moldboard removed were used to prepare the seedbed for corn. By 1945 work with mulches indicated that it was feasible to use the residue from the preceding crops and avoid the labor of transporting and applying the mulch. At this time the experiment had expanded to include eight tillage treatments. The implements used were broad V sweeps, disk harrow, cover crop disk, and the moldboard plow. One plot received no preparation prior to planting.

CURRENT STUDIES

In 1945 it was felt that information was needed on the effect of the mulches on the crops following corn. Consequently, different corn mulching methods have been applied to crop-rotation systems which were designed to satisfy most of the requirements of the area studied. As the experiment progresses, a value can be obtained for the effect of the different corn tillage treatments on the crops following corn in the rotation. It may also be possible to determine whether or not there are accumulative effects from the different corn-tillage treatments.

Location of Studies. Studies on the Purdue-Throckmorton Farm, 8 mi south of Lafayette, are on the Carrington and associated soils which commonly occur in the west central part of Indiana. These soils represent an area of relatively slow draining silt loam and silty clay loam prairie soils. Certain parts of this area have moderate to severe erosion problems.

Studies in Noble County are on the Miami silt and sandy loams and associated soils of northeastern Indiana. This section of the State has severe erosion problems because the slopes are steep and badly broken. Terracing and contouring in this area are generally not practical because of the broken and irregular terrain.

Design of Experiment. The Throckmorton Farm experiment has a four-year rotation of corn, soybeans, wheat, and meadow, and the Noble County experiment has a three-year rotation of corn, oats and meadow. Both experiments provide four replications of each treatment for each crop, every year.

Residue Mulch Tillage Methods — Advantages and Problems. The present experiment has eight tillage treatments which can be divided into three major groups: residue left on the surface, residue mixed through the upper few inches of soil, and residue turned under.

Residue Left on the Surface. Residue left on the surface gives the greatest protection from erosion. It acts as a canopy to lessen the impact of the raindrops and also as a "sponge" in retaining water on the soil. It helps to keep the soil in a loose and friable condition so that rainfall can be readily absorbed.

One problem that should be solved is that of finding a satisfactory method of preparing a loose seedbed to a 7-in or greater depth, and maintaining the residue on the surface. Two methods have been used for the past few years, using the lister bottom and the sweeps.

The difficulties involved in the use of the sweep as a primary implement for preparing the seedbed for corn are: (a) the sod is left in long strips with little pulverization or loosening of the soil, (b) shallow-rooted plants are retarded but not killed in the initial tillage, (c) the sweep requires a lower soil moisture content than the plow, and (d) corn stands have

been poor because there is not enough loose soil to cover the seed at planting time and the stand is further reduced by cultivation because of damage by clumps of vegetation which are moved and sometimes cover the corn plants.

The first problem in surface-residue treatments is the development of new machines or modification of existing equipment which will loosen the soil to the desired depth without mixing the residue with the soil to the extent that its effectiveness as a mulch is reduced. If the growing vegetation has been killed at the time of seedbed preparation, subsequent cultivations will not be difficult if disk hillers are used next to the row and small cultivating sweeps between the rows.

The second problem is the development of new planting equipment or modification of existing planting equipment that will plant through the mulch. The equipment used to date has not been satisfactory because the residue prevents the penetration of the planting mechanism to a uniform depth, and the machine has a tendency to move the residue out of the row and collect it on the planting mechanism.

One of the most satisfactory methods of maintaining the residue at the surface has been the strip preparation. This method consists of opening a seeding strip with a lister bottom and going just deep enough to move the residue to the side. A spring-tooth field cultivator has been used to prepare the seedbed in the strip. When this is done, enough loose soil is available to cover the seed and adequate stands can be obtained.

When the strip method was used for preparing the seedbed, cultivation has been difficult. The growing vegetation between the strips can be killed by using small sweeps in subsequent cultivations. However, at the time of the first cultivation, the corn is not large enough to withstand the large clumps of residue and soil which fall onto some of the plants in cultivation and a reduction in stand results.

Mixing of Residue Through the Surface Few Inches of Soil. Residue maintained on the surface involves certain problems that can be reduced or eliminated by mixing the residue into the upper few inches of soil. However, some of the effectiveness of residue as a mulch is lost when part of the residue is mixed below the surface of the soil. In this experiment, three methods have been used to prepare mixed residue seedbeds for corn. They are disking with the disk harrow, disking with the cover-crop disk and the use of a special plow and disk harrow.

The disk harrow has been satisfactory as an implement for shallow mixing of the residues, providing the disks are sharp and the amount of residue is not excessive (not over 5 tons per acre.). When large amounts of residue are to be mixed through the surface 3 in of soil, some preliminary tillage may be necessary. This can be done with either a plow (plowing very shallow, merely turning over the turf) or a field cultivator. The disk requires drier soil than the plow for efficient operation. On the heavier soil, yields with this type of tillage have not been entirely satisfactory.

The cover-crop disk, which is a large disk harrow, has been used to prepare a seedbed to approximately a 6-in depth and to mix the residue through that depth. The residue in this method is mixed to a greater depth than can be accomplished with the ordinary disk harrow. However, this method leaves even less residue on the surface. Experience shows that to achieve a 6-in depth with the cover-crop disk, additional weights are necessary and it may be necessary to plow to a depth of 3 to 5 in before the cover-crop disk is used.

A third method of preparing the seedbed by mixing the residues through the surface is by use of a special plow. This plow has one moldboard with an attached share which is operated at a 3-in depth. A second share is slightly behind and 4 in below the top share. When this plow is followed by a disk harrow, the residue is mixed about 3 in deep and the depth of tillage is about 7 in. This method has the advantage of erosion control offered by the disk harrow and makes possible the depth of tillage which seems to be necessary for good corn production on the silt and clay loam soils.

One of the problems of mulch tillage has been nutrient deficiency because of the competition between the growing crop and the organisms decomposing the residue. Nitrogen is the element which is most likely to be deficient under mulch culture. In 1948, a fall-tillage treatment was established, the object being to minimize nitrogen deficiency. This method of treatment was designed to permit the decomposition of the residue through the fall and winter and the early part of the growing season, so that the maximum rate of decomposition would not coincide with the maximum growing period of the corn. The fall preparation consists of plowing with a moldboard plow to a depth of 1½ in. The following spring the seedbed is prepared with the special plow and the disk harrow. The fall tillage does not disturb the surface cover enough to cause a serious erosion hazard and the grass makes a good growth in the spring. For this reason, the soil is not subject to serious erosion until after the corn is large enough to give some canopy protection. However, by the end of the growing season the residues may have so completely disintegrated that the mulch protection is only slightly greater than the ordinary plow method.

Where the residue is mixed through the surface few inches of soil, stands have been quite uniform and cultivation has not been difficult when disk hillers were used next to the row and small cultivating sweeps between the rows. Of the three methods of preparing the seedbed by mixing the residue, the disk harrow method is most likely to cause trouble in cultivating because growing vegetation may not be completely killed in preparing the seedbed.

Residue Turned Under. Turning the residue under is the least desirable from the soil and water conservation standpoint. In this method, the ordinary plow is used and the seedbed is prepared with the disk harrow. This has been the method used by most farmers in Indiana, and it is used to measure the effectiveness of the other treatments with respect to both yields and conservation benefits.

Fig. 1 (*Left*) Sand deposited by erosion after last cultivation, at foot of 85-ft plowed plot (above thumb). No noticeable deposits from mulched plots • Fig. 2 (*Center*) Ground cover on plowed plots which permitted erosion causing sand deposit shown in Fig. 1 • Fig. 3 (*Right*) Ground cover on mulched plot prevented erosion comparable to that shown in Fig. 1, from plowed plot

Results and Observations. In 1949 a study was made to determine the amount of residue remaining in the soil at the end of the corn-growing season, as this amount could be used as an indication of the effectiveness of the methods in controlling erosion. This residue was primarily timothy with some alfalfa and red clover. The amount of residue was computed from samples taken in the field by a core sampler. This sampler was capable of securing a sample 10 in long and 3 in in diameter. Each sample was then divided into 2-in segments. The residue in each segment was washed free of soil, collected on a forty-mesh sieve, oven-dried, weighed and the amount per acre calculated.

Because cultivation tended to move the residue into the row, samples were taken at 4 and 15 in from the row. The average of these two samples is considered representative of the amount of residue remaining at the end of the growing season. The results of this study are given in Table 1. This

TABLE 1. RESIDUE REMAINING IN THE SOIL ON MULCH TILLAGE EXPERIMENTAL CORN PLOTS IN LATE AUGUST, 1949 PURDUE-THROCKMORTON FARM, LAFAYETTE, INDIANA

Treatment prior to planting			Residue in tons per acre*	
Residue location	Depth of tillage, in	Implement used	In upper 2 in	In upper 10 in
Residue left on surface	6 to 7 Strip only	Lister bottom and spring-tooth cultivator in strip only	3.5	5.5
Residue left on surface	3 and 7	Sweeps	2.8	3.9
Residue mixed 0 to 6 in	6	Cover-crop disk	2.0	4.1
Residue under 4 to 7 in	7	Ordinary plow	0.8	3.5
Residue mixed 0 to 3 in	7	Ordinary plow† Special plow and disk	1.2	3.3

* Average amount of residue in tons per acre, measured 4 and 15 in from the rows.

† Ordinary plow in fall, 1½ in depth. Special plow and disk in spring to mix residue 0 to 3 in and tilled 7 in deep.

one season's study of the residue remaining late in the growing season of corn indicates that the fall mixing of the residue with the soil hastens decomposition and that the fall treatment approaches ordinary plowing in the amount of residue remaining for protection from erosion the following summer.

The yield of the crop is of primary importance in considering the tillage practices to be recommended. However, when the use of crop residues as a mulch can substantially reduce erosion and keep the field in high production, a slight reduction in yield is permissible.

The mean yields of the various tillage treatments for the period 1945-1948 are given in Table 2 and represent four

TABLE 2. AVERAGE CORN YIELDS (1945-1948) FOR SIX DIFFERENT METHODS OF PREPARING THE SEEDBED FOR CORN

Treatment prior to planting			Yield, bushel per acre	
Residue location	Depth of tillage, in	Implement used	Noble County* Miami silt loam	Throckmorton farm† Carrington silt loam
Residue left on surface	3	Sweeps	50	64
Residue left on surface	3 and 7	Sweeps	50	77
Residue mixed 0 to 3 in	3	Disk harrow	57	76
Residue mixed 0 to 6 in	6	Cover-crop disk	60	82
Residue mixed 0 to 3 in	7	Special plow and disk	59	81
Residue under 4 to 7 in	7	Ordinary plow and disk harrow	58	96

* Lowest Significant Difference, 5 per cent Noble County, 5 bu.

† Lowest Significant Difference, 5 per cent Throckmorton Farm, 7 bu.

replications of each treatment each year. The fertilizer was applied at the rate of 500 lb of 8-8-8 per acre at the time of planting (375 lb of the fertilizer was applied in a band 3 in below the seed and 125 lb at seed level). Using the 1945-1948 period for yield comparisons, we find that the use of sweeps at the 3-in depth gave unfavorable results at both locations. When the sweeps were used at the 3- and 7-in depths, unfavorable results were obtained on the lighter Miami and associated soils. It is believed that the poor results of the surface mulch are not entirely because of the location of the residue but to insufficient preparation of the seedbed.

The shallow mixed residue treatment may be advantageously used on the lighter soils but its use is questionable on the heavier soils. The heavier soils require better seedbed preparation.

In the fall of 1948, fertilizer was applied to the 1949 corn area. The rate of fertilization was increased to 1000 lb per acre; of this 700 lb of 8-8-8 was applied in bands 8 in deep and 24 in apart and 300 lb was broadcast. On the Noble County plots, the 300 lb was 8-8-8 while on the Throckmorton Farm 3-12-12 was used. Starter fertilizer (3-12-12 Throckmorton Farm and 8-8-8 Noble County plots) was applied at the rate of 200 lb per acre at planting time at both locations.

Table 3 shows the corn yield for the 1949 experiments. The corn yields in Noble County exceeded the yields of the

TABLE 3. 1949 CORN YIELDS FOR EIGHT METHODS OF PREPARING THE SEEDBED FOR CORN

Treatment prior to planting			Yield, bushel per acre	
Residue location	Depth of tillage, in	Implement used	Noble County* Miami silt loam	Throckmorton farm† Carrington silt loam
Residue left on surface	6 to 7 Strip only	Lister bottom and spring-tooth cultivator in strip only	99	64
Residue left on surface	3	Sweeps	78	64
Residue left on surface	3 and 7	Sweeps	76	59
Residue mixed 0 to 3 in	3	Disk harrow	86	74
Residue mixed 0 to 6 in	6	Cover-crop disk	79	79
Residue mixed 0 to 3 in	7	Special plow and disk	103	72
Residue under 4 to 7 in	7	Ordinary plow	108	76
Residue mixed 0 to 3 in	7	Ordinary plow‡ Special plow and disk	98	84

* Lowest significant difference, 5 per cent Noble County, 17.4 bu.

† Lowest significant difference, 5 per cent Throckmorton Farm, 14.5 bu.

‡ Ordinary plow in fall 1½ in deep. Special plow in spring to mix the residue, 0 to 3 in with 7 in depth of tillage.

Throckmorton Farm for the first time in the experiment. The primary reason for this was more favorable rainfall in Noble County. Weather data show that from the first of July until the last of September, the Noble County area rainfall was about 10 in, whereas only about 5.4 in was recorded at the Throckmorton Farm. At the latter locality, the precipitation consisted of small rains which would allow relatively high evaporation losses. With more adequate rainfall in northern Indiana in 1949, some advantages of the moldboard plow method with respect to yield were realized. However, even under these conditions, some of the mixed-residue methods approached the plow method in corn yield.

Observations made throughout the growing season leave no doubt that erosion was serious where the residues were turned under in 1949. This was very noticeable at the end of the corn rows where the sand was dropped. Fig. 1 is a representative photograph of the deposition from erosion where the corn was on a 3 per cent slope and the rows 85 ft long.

(Continued on page 402)

Mulch Farming and Related Machinery Problems

By L. W. Hurlbut
MEMBER A.S.A.E.

IN THE mulch-farming system we can quickly recognize all of the perpetual machinery problems involved in providing time-tested practices of good crop husbandry plus the problem of working through and under a cover of crop residue. Furthermore, some of the problems involved in this system are related to its proper integration into a fully developed conservation program consisting of such practices as crop rotations, contour farming, terracing, and keeping rough land or waterways in grass. In general, this practice appears to be best adapted to the relatively dry or the warmer areas where a small delay in planting time is less serious than in areas with a shorter growing season.

The ways in which residues on the surface aid in maintaining a high infiltration rate into the soil, the conditions under which they reduce evaporation, the extent to which they prevent soil loss, or influence crop yields as compared with conventional methods of farming, are subjects that have been discussed in previously(1, 2, 4, 5, 6, 7, 8, 9)*. Also, a paper(3), entitled "Machinery Requirements For Farming Through Crop Residues," was presented before this society in 1941, under the joint authorship of Dr. F. L. Duley, senior soil conservationist, (research), Soil Conservation Service, USDA, and Dr. J. C. Russel, cooperative agent and professor of agronomy, University of Nebraska. A later publication(5) discusses new, as well as remodeled machines adapted to this system. Research on the utilization of crop residues for mulches in Nebraska by Duley, Russel and others extends over a period of more than ten years.

There are at least two basic problems involved in utilizing crop residues for mulches, and, as one might expect, both of them have agronomic and engineering implications. They are (a) to provide a seedbed as good at seeding time as can be gotten with timely plowing and secondary tillage operations and (b) to keep the crop residue on or near the surface of the soil during the sequence of seeding and tillage operations.

Primary Seedbed Preparation. Machinery problems in the primary tillage operations are similar in essential features for the various crops produced. Unfavorable soil-moisture conditions may require a "ripping" or vertical slicing operation to a depth of 5 to 6 in. Later a subsurface tiller or "horizontal cutter" is operated at approximately the depth of ordinary plowing. The first operation serves to break up the hard soil so that the subsurface tiller can penetrate to the desired depth and the second operation serves to stir the soil and kill weeds. Under ideal soil conditions, a satisfactory primary seedbed can be obtained by one cultivation with a subsurface tiller.

In some instances it may be desirable to cut or break residue containing long or coarse stems to facilitate the operation of the tillage machines. In other cases where there is exceptionally heavy residue, such as a heavy cover of wheat straw, the use of a one-way disk or similar tool for the first primary operation may be desirable and may make it possible to mix part of the residue with the soil and thereby accelerate decay of the excess material. In some cases it may be more practical to remove part of the residue for other uses.

Secondary Seedbed Preparation. The sequence of operations for secondary seedbed preparation are basically the same as for clean fallow farming. The objectives of these operations are to manipulate and form the seedbed, break the surface clods, kill weeds, and in some instances provide better distribution or breaking of the residue to facilitate the seeding operations. Where weeds are a problem, one or more shallow cultivations with a subsurface tiller may be necessary.

A "treader" is an effective tool for secondary tillage. When the axis of the gangs are set perpendicular to the direction of travel, it serves as a subsurface packer. When the gangs are angled with respect to each other and to the direction of travel it is called a "skew" treader and produces both a packing and a weeding effect. In western sections of Nebraska where rainfall is quite limited, the rod weeder is a very effective machine for secondary tillage operations.

Seeding Operations. The primary machine problem in seeding operations for small grains is a furrow opener which will not raise the soil and place it on top of the residue. Ordinary grain drills with single-disk openers throw the soil too high and too far. In the wheat section of our state there is commonly too little residue remaining on the soil surface following the seeding operation. However, part of this trouble can be traced to a cropping practice which has wheat for two years followed by one year of fallow. In this case the heavy straw yielded following fallow may complicate the subsequent summer and fall land-preparation and seeding operations, whereas the lighter straw yield of second-year wheat must be used to provide protection throughout a comparatively long fallow period. An alternate wheat and fallow plan can provide an adequate and continuous crop residue cover for the soil.

Seeding row crops can be done quite effectively with a

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1949, as a contribution of the Soil and Water Division.

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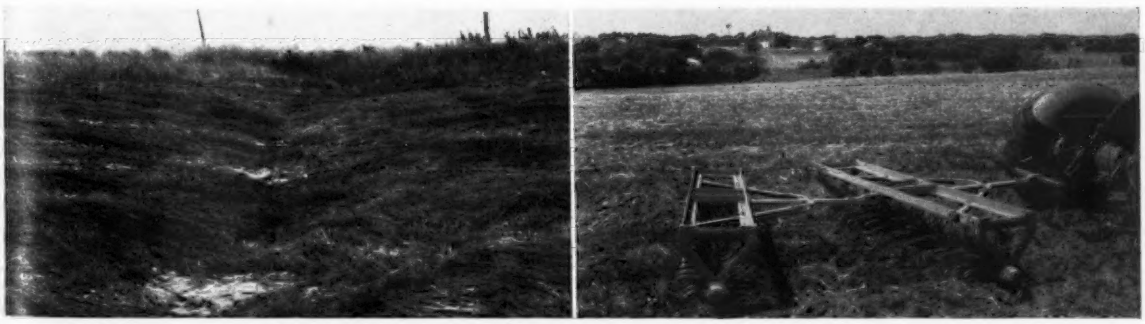
* Numbers in parentheses refer to the appended references.



(*Left*) Second-year, sweet-clover residue provides a good cover for soil which is being reseeded to grass • (*Right*) A "skew treader" is used for secondary operations in seedbed preparation and for first cultivation of corn planted in shallow furrows. (Photos courtesy of Dr. F. L. Duley, Soil Conservation Service)

planter equipped with stub runners and disk furrow openers or properly designed disk-type furrow openers. Subsequent cultivating operations include the use of a skew treader which moves soil to the plant rapidly and gently while filling the shallow furrow, destroying small weeds, and uncovering some residue covered at the time the furrow was opened. Standard cultivators equipped with large sweep-type shovels serve well for later cultivations.

The recommendation that the best way to handle badly eroded land is to put it back to grass is not without faults. This recommendation is complicated by the fact that erosion is generally continuing at a rapid rate and the remaining soil is so low in nitrogen it will not produce good grass without special treatment. An effective procedure, practiced in Nebraska, is based on fertilizing the soil with lime and phosphate so that a good growth can be obtained from a nitrogen-fixing legume, usually sweet clover. Subsequently the clover residue serves to protect both the soil surface and the young grass. The spring-planted clover may provide limited pasture in the fall and the following spring but sufficient plant material, at least two tons per acre, must remain to be cut prior to the seed stage for surface mulch. In some cases it may be desirable to cut the clover 12 to 15 in high followed later by a second cutting serving to reduce the material into shorter pieces. Subsequent operations may consist of breaking the residue with a treader or disk, subtilling, treading and finally a combined seeding and treading operation. A lime spreader has served fairly well for spreading light seeds such as brome grass.

The primary machine problems in re-establishing grass on subtilled land involves further development of treaders which may serve as common carriers for seeding machines, and the improvement of the seeding mechanisms now available.

In conclusion, the following machinery problems appear to be involved in keeping the mulch system of farming short of its ultimate value to Nebraska farmers:

1 There is need for a tillage machine, or tillage machines, which will provide a seedbed at seeding time as good or better than that produced by clean fallow provided by the plow and its complementary secondary tillage machines.

2 Secondary tillage and seeding machines are needed to provide a field surface capable of resisting the movement of residue by the wind, but which will not mix the residue with the soil, yet still eliminate the weeds.

3 Better design for soil-working units and adequate clearances between them, so that they will operate satisfactorily through a heavy residue cover. A practical method of reducing the coarse and long stems contained in the residue might relieve this problem somewhat.

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Mulch Tillage for Corn

(Continued from page 400)

The fall tillage method yield was favorable at both locations. Its effectiveness as a conservation measure is being further investigated. The strip preparation has been among the best with regard to yield on the lighter soils.

CONCLUSIONS

At present, the conclusions we can draw from these experiments are as follows:

1 Crop residues used as mulches offer possibilities for erosion control and moisture conservation on land where contouring operations are not feasible.

2 Subsurface tillage with the residue left on the surface has resulted in the lowest yields and best erosion control.

3 Mixed-residue tillage methods produced corn yields as high or higher than plowing on the lighter soils and substantially better control of erosion.

4 Plowing has resulted in the highest yields on the heavy soils, but it affords unsatisfactory protection from erosion without supplementary conservation practices.

5 It is easier to plant and cultivate corn on plowed ground than where the residue is retained on the surface or mixed into the surface few inches of soil.

ADDITIONAL STUDIES

In 1948 and 1949, field tests were made at Lafayette, using a large spring-tooth field cultivator with small wing sweeps attached about 2 in above the "bull tongue" points. This implement was used to prepare the seedbed for corn on the heavier soils. Since the implement can penetrate to a 10- to 11-in depth, it prepares a deep seedbed. Disking then mixes the residue through the surface 3 in of soil. The resulting yield has been very favorable for the two seasons.

In 1948, no comparisons were made because the area used was isolated and the entire area was prepared with the spring-tooth field cultivator. The yields are given in Table 4.

TABLE 4. CORN YIELDS WITH SEEDBEDS PREPARED BY THE SPRING-TOOTH FIELD CULTIVATOR

Year	Tillage treatment	Fertilization per acre	Yield, bu per acre
1948	Spring-tooth field cultivator	200 lb 8-8-8 starter fertilizer only	106
1949	Spring-tooth field cultivator	700 lb 8-8-8 in bands 8 in deep 24 in apart. 200 lb 3-12-12 starter fertilizer	124
1949	Spring-tooth field cultivator	200 lb 3-12-12 starter only	117
1949	Ordinary plow	200 lb 3-12-12 starter only	117

Problems needing further attention for satisfactory mulching of corn in Indiana are: (a) developing or adapting implements that prepare a deep seedbed but leave sufficient residue to give adequate erosion protection throughout the growing season, (b) developing or adapting implements that will plant in or through residues and still maintain the residue over the entire area, (c) development of mulch-tillage fertilization practices that will overcome the temporary deficiencies of plant nutrients which tend to reduce corn yields with mulch culture.

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Farm Electrification Research by Electric Operating Companies

By W. J. Ridout, Jr.
MEMBER A.S.A.E.

THE electric industry turned to industry-wide studies and activities to meet the rural electrification problem in 1910, at the annual convention of the National Electric Light Association, then the industry's trade association.

Herman Russell, of the Rochester (N. Y.) Railway and Light Co., reported to the convention that his company was successfully sponsoring electrically-powered irrigation installations as drought insurance to farmers, and had found farm business an effective load builder. Urging the industry to give it increased attention, he foresaw a time when "electric lines in the country will be as common as telephone and telegraph lines are today, and the present investment in our central stations will be employed in making farms more productive, and life more worth living for both the farmer and the company."

In response to this call for action, the NELA organized a Committee on Electricity in Rural Districts. The report of this committee, an 87-page book published in 1911, is probably the first systematic collection of data on farm electrification.

In 1911 this committee recommended an investigation of types of farming machinery being manufactured, with a view to securing adaptations which might be necessary in their design to render them readily adaptable to motor drive.

By 1922 the stage was set for a national organization to attack the farm electrification problem on a wide front.

In 1923, the NELA Rural Lines Committee proposed to the American Farm Bureau Federation that a cooperative organization be formed to study the problem, and make available for the use of everyone concerned information on the following: (a) the various methods by which electrical energy can be profitably utilized on the farm, including research studies of equipment characteristics, as well as methods, and (b) the facts regarding the lines and equipment needed to give the farm electric service comparable in quality with that already given in the industrial field.

The Committee on the Relation of Electricity to Agriculture (CREA) was organized in September, 1923, with the NELA and the American Farm Bureau Federation taking the lead. Other interested groups, including the American Society of Agricultural Engineers, participated in the work of the Committee. The Committee, it was decided, would coordinate on a national scale the activities of all groups interested in farm electrification. It would sponsor and encourage research into new farm uses of electricity, widening the use of existing applications, reducing the cost of rural extensions.

State CREA committees were established in 27 states to carry on the actual work of research and experiment, it being planned that the national CREA would coordinate their work and publish the results.

Laboratory tests on farm applications suggested by CREA were conducted mainly by state colleges of agriculture and their experiment stations. Every known farm use of electricity was carefully examined for possible improvement. New equipment was developed, and exhaustive tests were made. Results and comparative costs were reported to the national committee, which published them in a series of bulletins.

Hundreds of publications were also issued by the state CREA committees, summarizing the results of their activities.

By 1935 the work of CREA had brought the basic problems of profitable supply and use of electric power to a point much nearer solution. Research and experimental work completed under its sponsorship had equipped agriculture, the utilities and the manufacturers with basic facts without which the general application of power to farm operations that has since developed would not have been possible.

Our report (of which this is an abridgement) is a compilation of research and special study projects completed since January 1, 1947, and those projects that are authorized but not yet started. These projects are, or will be, conducted by electric operating companies. We have, of course, included those projects to which electric operating companies have contributed and also those to which they have agreed to contribute. This report includes some basic research, quite a number of investigations, and some special studies. There are also a few analyses included. Research projects are included in this report but all the projects mentioned are not strictly research.

The Farm Section of the Edison Electric Institute has decided that it will make annual reports in the future on this subject. We hope that our first revision will be all-inclusive.

Included in this report are 180 projects dealing with 75 different types of problems from developing a garden pea sheller to the study of electronics and radio frequencies adapted to agricultural research. Some of these projects are minor and are not too important nationally, but I dare say they are extremely important to a particular local area. Ninety-six of these electric company projects are or will be conducted jointly with land-grant colleges, the USDA, or by a group of electric operating companies. Eighty-four projects are being conducted by individual companies. Hay drying leads in the number of projects, with 15 in 11 different states. There are 10 projects in grain drying reported from seven states. Processing of farm crops was found to be the major enterprise, and there are over 50 projects included in this report that deal with processing techniques. In Idaho the CREA committee has a project on cheese curing. One of Indiana's main projects is grain drying. Oregon is interested in gladiola bulb storage. At the Wisconsin Research Farm they are developing a machine to elevate grain, mix it, and grind it; Kansas is attempting to evaluate the problems concerned in farm-scale dehydrating; Connecticut Light & Power Co. is developing a heavy-duty device for extracting juice from fruits on the farm. In Maine they are studying the problem of potato house ventilation. In Texas and California they are studying rice drying.

Thirty-eight projects were reported involving the dairy, including dairy barn ventilating, dairy water heating, milkhouse and milking parlor heating, milk pasteurization, milk cooling, calf dehorning, barn cleaning, and many others. There are eight different projects on dairy barn ventilation. Electric operating companies are cooperating in Illinois, Maine, Minnesota, New York, Pennsylvania, Vermont and Oregon on dairy barn ventilation projects.

The work going on involving the applications of electricity on the poultry farm stands out in this report. There are 25 projects on problems including bactericidal lamps in laying houses, brooding, egg candling, egg cooling, egg-room heating, poultry house ventilation, poultry growing, floor heating, automatic water supply, and water warming.

Six projects on brooding are reported. Five of these projects are set up to study new methods of brooding, such as the use of infra-red lamps, and the use of soil-heating cable. There is no question about it, we still have to find the answer to the application of electricity on the farm.

Getting back to the dairy and the dairy barn, complete new design of the barn is predicted, in which two applications of electricity have been influential — the barn cleaner and the electric cow trainer. They have found on the Wisconsin Electric Research Farm that with the use of this equipment the barn would need to be only *(Continued on page 408)*

Abridged report presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., as a contribution of the Rural Electric Division.

The author: W. J. RIDOUT, JR., is rural service manager, Edison Electric Institute.

NEWS SECTION

North Atlantic Section Program

AN ATTRACTIVE program has been arranged for the meeting of the North Atlantic Section of the American Society of Agricultural Engineers, at the University of New Hampshire, Durham, August 28 to 30. The meeting headquarters will be in Congreve Hall and registration will begin on Sunday, August 27, from 6 to 8 p.m. Dormitory accommodations are being provided in Congreve Hall for those attending the meeting and will be available for occupancy at 2 p.m. on Sunday. For complete information on accommodations, interested persons may contact H. N. Colby, chairman of the local arrangements committee for the meeting.

The meeting opens on Monday forenoon, August 28, with a general program featuring a welcome talk by Dr. A. S. Adams, president, University of New Hampshire, and an address entitled, "If", by J. L. McCaffrey, president, International Harvester Co. G. H. Arris, financial editor, Providence Journal-Bulletin, will give a talk on power resources of New England, and R. R. Macleod, Niagara Mohawk Power Corp., will speak on "Freedom Isn't Free."

Three concurrent programs are planned for the afternoon of the first day on power and machinery, farm structures, and a joint soil and water and rural electric program. The power and machinery program will include papers on equipment for weed control by R. E. Patterson, Pennsylvania State College test procedure for hay blowers by E. D. Longhouse, University of West Virginia, and on the functions of a research department in a farm machinery company by B. B. Coxworth, Massey-Harris Co. Three papers will also be presented on the farm structures program: First, pen stabling in New England by Angus Banting, Nova Scotia Department of Agriculture and Marketing; second, design of milking parlors and their advantages and disadvantages by K. S. Morrow, University of New Hampshire; and thirdly, recent designs in dairy stalls by D. P. Brown, West Virginia University. The joint soil and water and rural electric program has three papers scheduled—one on the types and uses of supplemental irrigation equipment by F. W. Peikert, University of Maine; a second on developing water supplies for irrigation by Robert Cushman, U. S. Geological Survey; and a third on pumping water for soil irrigation by Harold Gray, Cornell University. Immediately following these papers will be three tours, one to a campus pasture irrigation research project, a second to the university dairy barn to view pen stabling, and a third in the form of a field trip to a drainage project on the university farm.

C. L. Hamilton, National Safety Council, will open the Monday evening program with a talk on farm safety, at a general session, and Melvin Moul, farmer, Brentwood, N. H., will give an illustrated talk on construction and operation of one of the largest poultry laying houses in the United States, at a joint rural electric and farm structures program to conclude the first day's meeting program.

A.S.A.E. Meetings Calendar

August 28-30—NORTH ATLANTIC SECTION, Congreve Hall, University of New Hampshire, Durham

October 19 and 20 — PACIFIC NORTHWEST SECTION, Commercial Hotel, Yakima, Wash.

October 20 and 21 — PENNSYLVANIA SECTION. Brunswick Hotel, Lancaster, Pa.

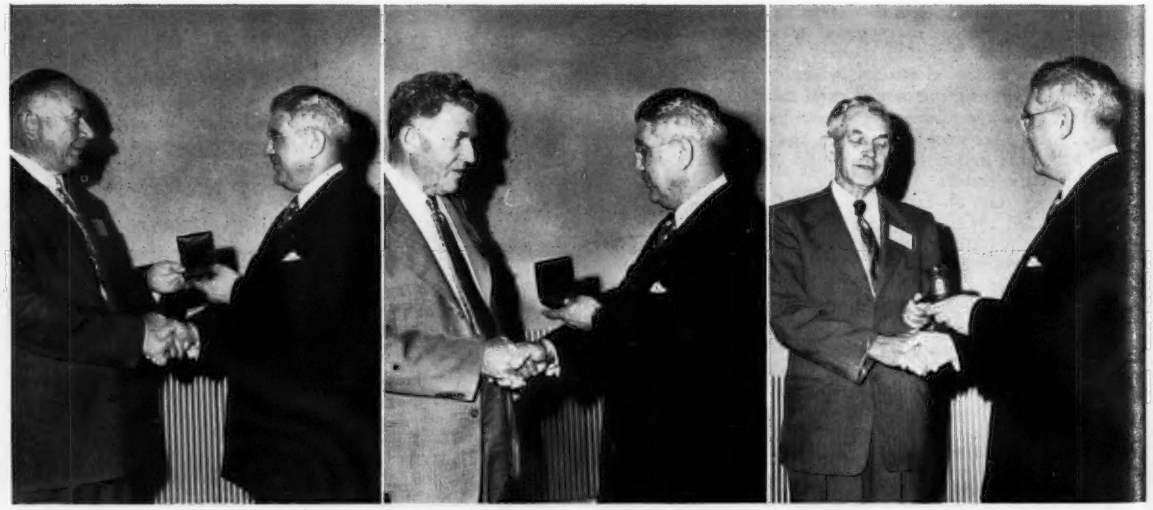
December 18-20 — WINTER MEETING, The Stevens, Chicago, Ill.

June 18-20 — ANNUAL MEETING, Rice Hotel, Houston, Tex.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to A.S.A.E., St. Joseph, Michigan

Three concurrent programs, soil and water, power and machinery, and a joint farm structures and rural electric, are scheduled for the afternoon of the second day, Tuesday, August 29. The soil and water program will consist of four numbers: The effect of rainfall characteristics on soil erosion by W. D. Ellison, U. S. Navy; stream bank erosion control by Kenneth Wilson, SCS, USDA; the design of farm ponds for the Northeast by W. S. Atkinson, SCS, USDA; and setting up a farm drainage program by J. A. Roberts, New Brunswick Department of Agriculture. The power and machinery program will feature three papers: the economics of farm mechanization in the Northeast by E. P. Brodell, Bureau of Agricultural Economics, USDA; power and machinery research in progress by R. B. Gray, division of farm machinery, USDA; and the dealers' function in modern mechanization by R. C. Burnette, New York Farm Equipment Dealers' Assn. Following two papers on a joint farm structures and rural electric program, one on the need of automatic control and recording instruments in agricultural engineering research by J. H. Broome, Minneapolis-Honeywell Regulator Co. and the other on automatic ventilation of common storages by Dr. J. H. L. Truscott, Vineland (Ontario) Experimental Station, the rural electric group will listen to a paper on molasses pumping equipment for grass silage and stable feeding by J. W. Crofoot, G. L. F. Farm Supplies. The rural electric and farm structures group will conclude the morning session with a field trip to one of the largest multistory brooder houses in New England on the farm of R. W. Canney, Rochester, N. H.

A general program is planned for the afternoon of the second day and will feature a talk on changes in agriculture and their relation to youth programs by Stanley Warren, Cornell *(Continued on page 406)*



In carrying out the final duties of his office as President of the American Society of Agricultural Engineers, Frank J. Zink is shown here (at the right in each picture) awarding the Cyrus Hall McCormick gold medal to Arnold P. Yerkes (left view), awarding the John Deere gold medal to Roy B. Gray (center view), and inaugurating his successor, Fred C. Fenton (right view), as the new President of the Society for the year 1950-1951. The awards and inauguration ceremonies took place on the occasion of the Society's annual dinner at Washington, D. C., June 21, 1950

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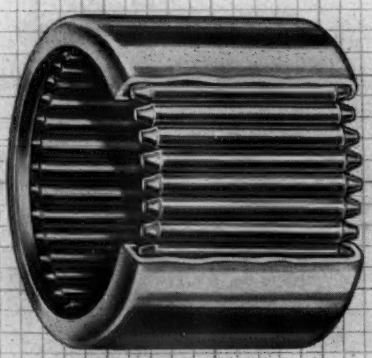

You can save in first cost—Needle Bearings are only slightly more expensive than plain bearings and cost much less than conventional ball or roller bearings.

You can save in design — only three elements are needed, a plain bore housing, a hardened and ground shaft and the Needle Bearing.

You can save in machining — housings are straight-through without shoulders or grooves.

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Secure these savings *now* by asking a Torrington engineer to help you adapt anti-friction Needle Bearings to your products.

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TORRINGTON *NEEDLE* BEARINGS

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NEWS SECTION

(Continued from page 404)

University, followed by reports of youth activities from each state in the Section. Papers will also be presented by Henry Simons, farm service representative, New York State Electric and Gas Corp., on a system for supplying agricultural engineering information to teachers and agents, and by C. M. Edwards, Cornell University, on some results of a study of mechanical preferences of boys and girls.

A business meeting of the Section will be held immediately following the close of the afternoon program.

The annual Section dinner will be held on Tuesday evening, August 29, at Simpson's on Great Bay, and will commemorate the 25th anniversary of the Section. Lawrence Whittemore, president, The Brown Co., has been secured as the banquet speaker for the evening.

The meeting will terminate on the forenoon of Wednesday, August 30, with a general program on grassland farming in the Northeast. Five speakers will discuss this subject as follows: why grassland farming in the Northeast by J. B. Abott, farmer, Bellows Falls, Vt.; pasture irrigation in grassland farming by Ray Foss, Shepard Irrigation Equipment Co.; silage equipment for grassland farming by F. H. Hamlin, Papec Machine Co.; the place of mow hay curing in grassland farming by M. E. Sergeant, Central Vermont Public Service Corp.; and self-feeders and self-feeder equipment in a grassland farming program by C. H. Reed, Rutgers University.

The meeting will be officially adjourned at noon, but a tour has been arranged to the Portsmouth Navy Yard in the afternoon as a final climax to the three-day meeting.

Nominations for ASAE Medal Awards

IN ACCORD with the rules governing the award of the John Deere and Cyrus Hall McCormick Gold Medals, the Jury of Awards of the American Society of Agricultural Engineers will receive from members of the Society, up to November 1, nominations of candidates for the 1951 awards of those two medals.

Members of the Society nominating candidates for either award are requested to keep in mind the purposes of each medal and make their nominations accordingly. The John Deere Medal is awarded for "distinguished achievement in the application of science and art to the soil," which citation is interpreted to cover more than a mechanistic concept of engineering, and to include chemistry, physics, biology, and any other science and art involving the soil, the "application" being acceptable to "evaluation by the engineering criteria of practicality and economic advantage."

The Cyrus Hall McCormick Medal is awarded "for exceptional and meritorious engineering achievement in agriculture." Selections for the award may be in recognition of a single item of engineering achievement, but is more likely to be on the basis of the aggregate of weighted accomplishment through a continuing career.

The Jury of Awards desires that members of the Society consider it their duty and obligation to give serious thought to the matter and nominate for either or each of these awards the men they believe to be most worthy of the honor. Each nomination must be accompanied by a statement of the reasons for nominating a candidate and qualifications of the nominee, including his training, experience, contributions to the field of agriculture, a bibliography of his published writings, and any further information which might be useful to the Jury in its deliberations.

The Jury will accept and consider nominations received on or before November 1, and these nominations should be addressed directly to the Secretary of the Society at St. Joseph, Michigan. The Secretary will supply on request a standard set of instructions for preparing information in support of nominees for the Society's gold medal awards; in fact, it is important that these instructions be followed in preparing material on behalf of any nominee.

Pennsylvania Section to Meet in October

THE executive committee of the Pennsylvania Section of the American Society of Agricultural Engineers announces a preliminary program for their fall meeting which will be held at the Brunswick Hotel, Lancaster, Pa., October 20 and 21.

Present plans for the meeting call for a farm tour on Friday morning, a trip through the New Holland Machine Company plant on Friday afternoon, and a banquet and round-table discussion for Friday evening. Timely papers will be presented at a one-half day general session Saturday morning, followed by a business meeting. Section members are invited to submit any suggestions they may have for program ideas.

Section members are reminded that this is the only meeting scheduled for the current year and are urged to make a very special effort to attend. The meeting will afford an excellent opportunity to combine the pleasure of a few days of relaxation and a trip through some beautiful country with the business of learning a lot while fostering the professional advancement of agricultural engineering.

Committee on Instrumentation Proposed

AROUND-TABLE meeting of an exploratory committee on instrumentation was held on June 19 at the Statler Hotel in Washington, in conjunction with the ASAE annual meeting. In addition to the appointed committee members—W. H. Kliever (chairman), J. R. McCalmont, W. V. Hukill, and O. C. French—there were fifteen other interested engineers in attendance from industry, the U. S. Department of Agriculture, and the colleges. This temporary group was appointed in April to investigate the need for such a committee.

As a result of this round table, the group recommended to the Council of the Society: (1) that a permanent committee be set up and that it be called the Committee on Instrumentation and Controls, (2) that the objective of the committee be to promote the use of instruments, both in agricultural research and agricultural production and processing through a variety of activities, and (3) that the membership of the committee consist of seven members, each a specialist in one of seven fields of activity, namely farm machinery, farm structures, rural electrification, soil and water, processing (including industrial), climatology, and instrumentation and control.

There is need not only for information on the use of instruments, but also for maintenance and calibration. It was suggested that members who have used instruments successfully in agricultural work be asked for detailed information. In disseminating information, it was pointed out that the problem of the committee will be to provide information about known instruments, to encourage the development and adaptation of new instruments, and to serve as a clearinghouse for information about them.

It is expected that such a committee will shortly be appointed by the President of the Society. *(Continued on page 410)*

This view shows part of the group of 125 members and guests of the American Society of Agricultural Engineers who attended the meeting of the Society's Pacific Coast Section held March 16 and 17, 1950, at Logan and Salt Lake City, Utah

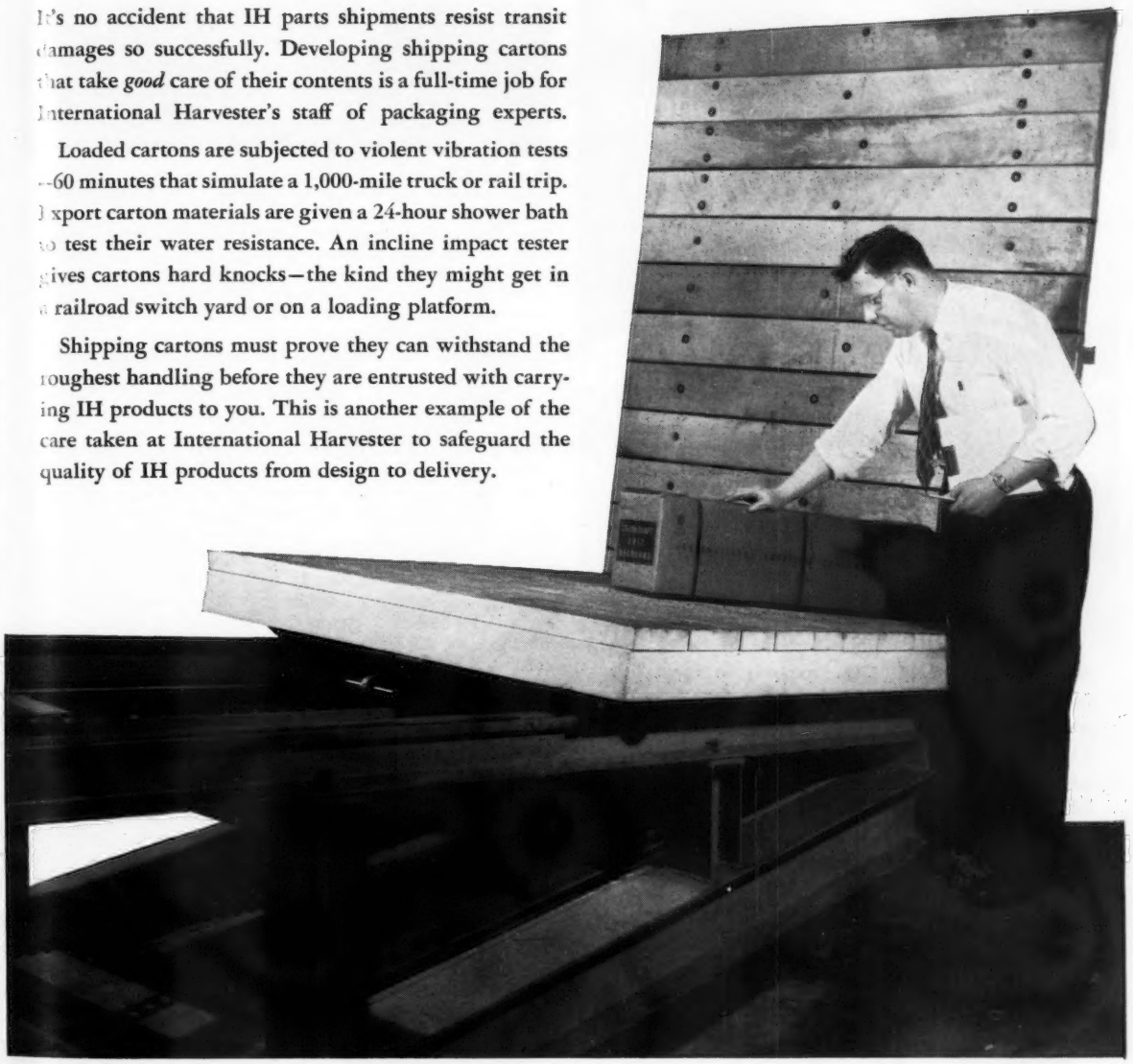
Why IH Parts Reach You Factory-Fresh

A report to you about men and machines that help maintain International Harvester leadership

It's no accident that IH parts shipments resist transit damages so successfully. Developing shipping cartons that take *good* care of their contents is a full-time job for International Harvester's staff of packaging experts.

Loaded cartons are subjected to violent vibration tests—60 minutes that simulate a 1,000-mile truck or rail trip. Export carton materials are given a 24-hour shower bath to test their water resistance. An incline impact tester gives cartons hard knocks—the kind they might get in a railroad switch yard or on a loading platform.

Shipping cartons must prove they can withstand the roughest handling before they are entrusted with carrying IH products to you. This is another example of the care taken at International Harvester to safeguard the quality of IH products from design to delivery.



Impact tests simulate railroad switching jolts. Here is an IH researcher examining a loaded crankshaft carton that has been slammed against the rigid plank wall eight times—at a rate equivalent to top switching speeds. He's finding out whether the package will cushion the jolts and jars of railroad switching. Only cartons that provide complete protection for their contents may wear the IH trade-mark.

International Harvester Builds McCormick Farm Equipment and Farmall Tractors . . . Motor Trucks . . . Crawler Tractors and Power Units . . . Refrigerators and Freezers . . .

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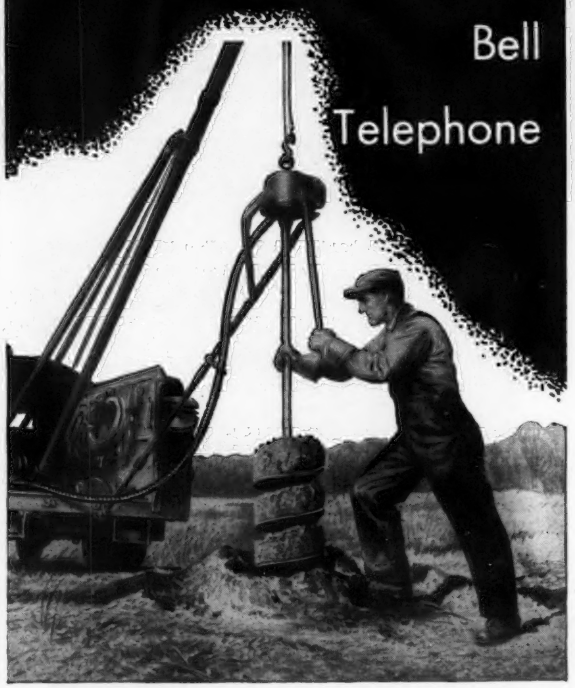
STOW case history #1

STOW *flexible shaft*
on the job for
Bell
Telephone



BELL TELEPHONE CO. experts in rural line maintenance select their equipment for all-around, all-weather, on-the-job dependability. The above illustration shows a STOW Flexible Shaft transmitting power to one of the POST-HOLE DIGGERS used by BELL TELEPHONE CO. in maintaining rural power lines. STOW Flexible Shafting can solve **your** probems in power transmission. Write today for your handy STOW TORQUE CALCULATOR — and further information on unique applications of **STOW FLEXIBLE SHAFTING!**

Send for your free copy

LEARN HOW STOW FLEXIBLE SHAFTS HAVE BEEN SOLVING POWER TRANSMISSION PROBLEMS SINCE 1875.

STOW MANUFACTURING CO.
39 SHEAR ST. BINGHAMTON, N. Y.

Charles E. Seitz, head, agricultural engineering department, Virginia Polytechnic Institute, was honored by a group of 50 close associates and VPI agricultural-engineering graduates at a breakfast held at the Mayflower Hotel, Washington, D. C., on June 21. As a high light of the event, VPI graduates presented Mr. Seitz with a scroll in recognition of his outstanding contributions to the development of agricultural engineering in Virginia and the nation. M. M. Johns (left) made the presentation to Mr. Seitz (right). Mr. Seitz served as president of the American Society of Agricultural Engineers in 1932-33.

Farm Electrification Research

(Continued from page 403)

32 ft wide. The standard width of Wisconsin and possibly other dairy barns heretofore has been some 37 to 40 ft. The dairy barn can be made narrower to accommodate the same number of cows, since this eliminates the need of the wide driveway.

Automatic feeding of poultry will change materially the design of poultry houses. If Indiana can prove that night lighting is advantageous to the growth and fattening of hogs, we will see some changes in the design of hog houses. Along this line, the CREA in Idaho has a project on farm building construction. Northern States Power Co. is working on the design of lounging barns, milking parlors and milkhouses; the Toledo Edison Co. is planning a project for 1950 in cooperation with Libbey-Owens-Ford and Owens-Corning Glass Co., in the construction and study of a new poultry house. In a recent survey we found that out of 2377 farm customers in 19 states, 397 wanted farm freezers next. This piece of equipment led all others in demand by farmers. Renewed interest in the use of refrigeration on the farm is exemplified by the research work reported. There are refrigeration studies reported from Pennsylvania, Louisiana, Oregon, Idaho, Michigan, and Texas.

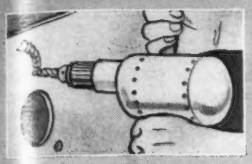
Kansas reports research work on the heat pump. The CREA group there is hopeful of the future use of this application, since there is usually an unlimited supply of water and ground space around the farmstead.

The application of panel heating on the farm for specific heat applications and possibly house heating has received considerable attention. The Ohio Power Co. is one of the companies planning to run tests on these panels this winter.

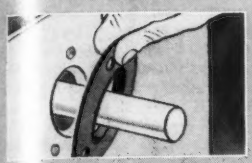
California is studying the problem of alfalfa leaf shatter and the determination of protein and carotene losses resulting from varying amounts of leaf shatter. Indiana is investigating the carotene destroying system in alfalfa by the treatment of plant tissue with heat energy. They have found that electrical conduction and ultraviolet light were ineffective; infrared radiation was only partially effective; while conduction heating with electrical plates and open-flame heating were effective in destroying enzyme activity with temperatures above 80 C.

Farm electrification research is increasing. There are remaining many problems in this field. The electric operating companies are standing ready to contribute in any way they can to further this worth-while work.

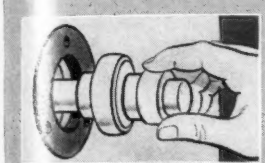
EASY TO INSTALL
NO COSTLY MACHINING



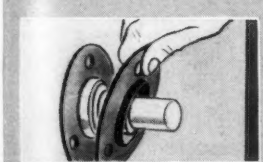
1 Provide holes in machine frame to accommodate flange cup and flange mounting bolts.



2 Slip one half of flange, with cup side facing assembler, over shaft.



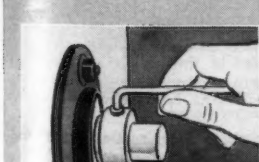
3 Slide bearing and collar on shaft.



4 Slip other flange over shaft with cup side toward bearing.

5 Line up bolt holes of flanges with bolt holes on machine, slide bearing into proper position and bolt unit in place. DO NOT TIGHTEN BOLTS.

6 Repeat for other end of shaft and then tighten bolts on both ends.

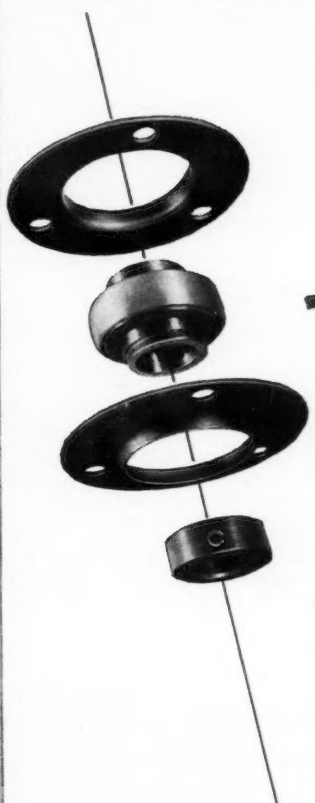


7 Engage locking collar by turning in direction of shaft rotation until ... in collar drops over cam on inner ring. Continue turning until cams lock. Tighten set screw.

Now you can equip your machines with ball bearings at **NEW LOW COST**

. . . with

NEW EASE of INSTALLATION



The Fafnir Flangette

incorporating the famous Fafnir Wide Inner Ring Ball Bearing with Self-Locking Collar

Now you can add ball bearing performance, power economy and longer bearing life to your equipment within your cost limits. A brand new, simple, low cost housing idea eliminates costly machining, makes maintenance easier. A pair of pressed steel flanges which can be bolted anywhere on your machine, provides a lightweight, compact, sturdy housing for a standard Fafnir Wide Inner Ring Ball Bearing. Curved contour of inside surface of flanges matches curving contour of bearing outer ring to provide full self-alignment when installing the unit. A twist of the collar locks bearing to shaft. Sealed both sides with Fafnir Mechani-Seals . . . a labyrinth design of interlocking steel plates. Write today for illustrated folder. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

As they make their plans... They Need Your Advice

THOUSANDS of American farmers look to agricultural engineers for advice when they make plans for constructing permanent farm buildings and improvements.

You will give farmers sound advice if you recommend concrete construction for farm structures and improvements. There are hundreds of places where concrete is the logical construction material, but there's no place where it is more needed than on the farm.

Concrete is durable, sanitary, decay-proof and ratproof. Its firesafety makes it the logical choice for farm use. In addition, its lifetime economy—moderate first cost, low upkeep and long years of service—make it a wise investment.

You can get free, illustrated literature that is helpful in designing and building economical, firesafe and long-lasting concrete buildings and improvements such as poultry houses, fruit storage plants, dairy barns, hog houses, machine sheds, milk houses, granaries and many other profit-making farm structures. This literature is distributed only in the United States and Canada.

PORTLAND CEMENT ASSOCIATION

Dept. 8-1, 33 W. Grand Ave., Chicago 10, Ill.

A national organization to improve and extend the uses of portland cement and concrete...through scientific research and engineering field work

 (Continued from page 406)

REPORTS OF ASAE COMMITTEES

Committee on Extension

THE Committee on Extension is comprised of 18 members, of which 10 represent the USDA and state colleges and 8 represent industry. The chairman of rural housing, safety, and youths' activities committees are also included.

The objective of the Committee is two-fold: (1) to promote closer cooperation between public agency groups and industry in extension activities, and (2) to study and promote more effective extension methods.

Every merchant, banker, lawyer, minister, and teacher in a farm community is a potential cooperator in the promotion of better agriculture. Our extension activities in agricultural engineering would be far astray if we did not give special consideration to these individuals.

Who should be more interested in rural electrification and the most efficient use of electricity than the dealer in electrical equipment and supplies? The same question may be raised regarding better selection and use of farm machinery and the farm machinery dealer; more efficient structures and the building supply dealer; fuel and oil and the oil dealer; soil and moisture conservation and the local banker.

If we in the extension and promotional field properly perform our assignments, we can depend on the above-mentioned groups and individuals to cooperate on extension activities and the adoption of more effective extension methods.

Some of the activities of the Committee on Extension were in evidence at the 1950 ASAE annual meeting, and included the following exhibits: demonstration and display models assembled by K. H. Hinchcliff; bulletins and classroom manuals by M. R. Dunk; agricultural engineering textbooks by T. E. Long; press and radio publicity by D. O. Hull; education by G. O. Schwab; youths' activities by C. M. Edwards; farm safety by V. S. Peterson and R. E. Heston; rural housing by Ruby M. Loper, and master movies by I. D. Mayer. These projects represent, for the most part, efforts to improve the tools of extension. In the future we might well devote more attention to procedures related to our first objective—the promotion of closer cooperation between industry and the extension service and those individuals in rural communities each group directs.

L. G. SAMSEL, Chairman
Committee on Extension, ASAE

Best Bulletins Selected

CONTINUING a popular feature of its activity in recent years, the ASAE Committee on Extension sponsored an exhibit of extension bulletins and related publications during the annual meeting of the Society at Washington, D. C., in June. Blue ribbon awards were made for publications in several classifications, as follows:

Best Bulletins (Public Agency): "Plan for Electricity," University of Tennessee; "Your Farm House Heating," U. S. Department of Agriculture; "A Home Freezer You Can Build," Oregon State College; and "Rural Sewage Disposal," Ontario Department of Agriculture.

Best Bulletins (Industry): "Tom Brent and His Tractor," Standard Oil Company (Indiana); and "Making Pay Dirt Last," Allis-Chalmers Mfg. Co.

Classroom Instruction Manuals (Public Agency): "4-H Manual for Mechanics Club — Second Year," Colorado A. & M. College; "Farm Electrification," University of Idaho; "Farm Electrification," University of Washington; and "Laboratory Notebook in Farm Machinery," Ontario Agricultural College.

Classroom Instruction Manuals (Industry): "Tractor Maintenance Leaders Manual," Standard Oil Company (Indiana).

Judges for the display were E. R. McIntyre and Roy Miller, U. S. Department of Agriculture; James Patterson, Standard Oil Co. (Indiana); Harold Nelson, Bert S. Gittins Advertising Agency, Milwaukee, Wis., and Mrs. Henry Giese, Ames, Iowa.

Considerations on which the publications were judged included organization, readability, attractiveness, low cost, and action inspiration.

Demonstration Models Sell Themselves

A FEATURE of the exhibits sponsored by the ASAE Committee on Extension, which attracted much attention at the recent annual meeting of the Society, was the second annual ASAE Demonstration Models' Contest.

The models exhibit included both the self-explanatory types and those which required step-by-step explanation.

Blue ribbons were awarded on a basis of the importance and usefulness of the subject demonstrated, adaptability of subject to use of demonstration models, quality of workmanship of demonstration, and portability. The winning exhibits were "Pen Stable with Pole Construction," shown by Ivan Bigalow, Cornell University; "4-H Tractor Maintenance Exhibit," exhibited by Ray McLien, (Continued on page 412)

there's a **JOB** to be done

TERRACES TO BE BUILT... and the Best and Fastest way to build them is with an AUSTIN-WESTERN POWER GRADER with its

ALL-WHEEL DRIVE

BEST and FASTEST . . . because every pound of weight is on a driving wheel; providing tremendous tractive effort, and doing the job smoothly and easily regardless of the nature of the soil.

ALL-WHEEL STEER

BEST and FASTEST . . . because rear steer can be used to offset the frame, moving the windrow farther and faster, and compacting the earth in the ridge just enough to achieve optimum density.

EXTREME BLADE REACH

BEST and FASTEST . . . because the blade can be extended far beyond the rear tire, and the ridge constructed and finished to the desired density, uniformity and surface smoothness.

✓ **No single machine will handle so many different kinds of soil conservation jobs so easily, quickly and economically as the Austin-Western Power Grader with its exclusive All-Wheel Drive for maximum traction in soft or rough ground; exclusive All-Wheel Steer for fast maneuvering, and powerful bulldozer attachment.**

AUSTIN-WESTERN COMPANY
Aurora, Illinois, U. S. A.

BUILDERS OF ROAD MACHINERY
Austin Western
SINCE 1859

Soil Conservation is your concern and ours

Your job and the jobs of everyone who sells to farmers depend on a prosperous agriculture. That's why American Steel and Wire Company has taken an active part in promoting soil conservation. You, too, can help by urging farmers to put soil conservation plans into immediate operation wherever they are feasible.

HOW FENCE AND WIRE PRODUCTS FIT INTO THE PROGRAM

U·S·S AMERICAN FENCE

offers the best means available for keeping livestock under control. Livestock should be excluded from wood lots, ponds and erosion-scarred areas that are being revegetated. In pastured areas, fence is an important TOOL OF FARM PRODUCTION that enables livestock to harvest their own feed.

AMERICAN WIRE FABRIC

is an excellent reinforcement for concrete dams, flumes, spillways and irrigation ditches.

TIGER BRAND WIRE ROPE

is used on earth-moving equipment, for hoists, tow ropes and other applications around the farm.

AMERICAN ELECTRICAL WIRE & CABLE

are used for REA lines and offer a type of cable for every farm use. Special rubber-covered cables are designed for underground use to distant wells and pumps.

Send for our booklets, "It's Your Top Soil," "The Wire Rope Handbook" and "Wire Fabric Manual."

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
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UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

UNITED STATES STEEL

(Continued from page 410)

Purdue University, and the "Solarometer," demonstrated by Frank Wagner, Libbey-Owens-Ford Glass Company.

K. H. Hinchcliff, a member of the Committee of Extension, in charge of the Demonstration Models' Contest, announces that next year the committee plans to have a separate division for slides and photographs of effective demonstration models where time, distance, and costs make it impractical to send or bring models to the meeting.

Winners 2x2 Slide Exhibit

G. O. SCHWAB, a member of the ASAE Committee on Extension in charge of the 2x2 slide exhibit and exchange, announces that the following slide sets were awarded blue ribbons at the 1950 ASAE Annual Meeting held in Washington, D. C.: "Safe Power Slides," G. I. Johnson, University of Georgia; "Tile Drainage on the Farm," K. W. Hotchkiss, Structural Clay Products Institute; and "Paved Barnyards," T. E. Long, Portland Cement Association.

Awards were given for slide sets consisting of ten or more slides. A description of each slide was submitted by the exhibitor. The sets were judged on the basis of subject matter, quality of pictures, presentation of the idea, and organization use in the slide set.

The exhibit was sponsored in the interest of improved visual aids. It gave agricultural engineers over the nation a chance to see what others have been able to capture photographically. It also gave them the unusual opportunity to enlarge their own slide collection by arranging for duplicates of sets in which they might be interested.

First Annual Master-Movie Contest

I. D. MAYER, a member of the ASAE Committee of Extension, in charge of the 1950 master-movie exhibit at the ASAE Annual Meeting in Washington, announces that the following films received top rating and were awarded blue ribbons: "Hydraulic Controls," by the J. I. Case Company; "Quality Milk With Less Labor," by the Portland Cement Association and "More Time For Living," by Westinghouse Electric Corporation.

Educational motion picture films produced since the 1949 ASAE Annual Meeting were eligible for entry in the competition. While only a small number of films were received, they were of high quality. The following criteria were used as a basis for judging and rating the films: Technical quality, freedom from annoying distractions and advertising, proper scene length, editing, do scenes tell the story in logical sequence, proper scene sequence, proper framing and picture area utilization, does film hold interest, narrator, educational value, and inspirational value.

Textbook Exhibit

INCLUDED among the exhibits sponsored by the Committee on Extension in connection with the 1950 ASAE Annual Meeting was one on new agricultural engineering textbooks. The exhibit was limited to recent academic texts written by agricultural engineers and already issued by the publisher.

According to T. E. Long, a member of the Committee on Extension in charge of this exhibit, the following books were shown at Washington: Rural Electrification Engineering, by Earp; Farm Buildings, by Wooley; Machines for the Ranch Farm and Plantation, by Turner and Johnson; Land Drainage and Reclamation, by Ayres and Scoates; Farm Gas Engines and Tractors, by Jones; Soil Erosion and Its Control, by Ayres; Farm Shop Practice, by Jones; Farm Machinery & Equipment, by Smith; Manual of Farm Shop Practice, by Jones; Farm Structures, by Barre and Sammet; Farm Work Simplification, by Vaughan and Hardin; Farm Buildings, by Carter and Foster; Farm Machinery, by Stone and Rural Water Supply and Sanitation, by Wright.

Allahabad Students Publish Journal

THE Agricultural Engineering Society, student organization of men in the professional agricultural engineering curriculum at Allahabad Agricultural Institute in India, recently published "The Agricultural Engineer" for the summer of 1950. It is a 6½ x 9½-inch journal of 20 pages and seven contributions on various phases of agricultural engineering progress in India.

One contribution is a paper on "The Testing of Agricultural Implements in Uttar Pradesh," by Mason Vaugh (Member ASAE), head of the agricultural engineering department at Allahabad. Others deal with tractors, soil conservation, courtyard design, and world population. Several pages are devoted to brief summaries of agricultural engineering work in progress in the various states of India.

Speakers who addressed the Society during the 1949-50 school year, and the subjects which they presented, are listed.

An editorial by J. S. Bali summarizes the conservavtion, mechanization, and professional agricultural engineering problems of the country and concludes with the thought that "An Indian Society of Agricultural Engineers must emerge."

(News continued on page 414)

Published by the **Ethyl Corporation** to help promote the most efficient type of farm power.

WHO'S WHO IN TRACTOR SALES.
Frank W. Bickford, Massey-Harris dealer of Le Roy, N. Y., was a farmer for fifteen years before going into the implement business six years ago. Because the farmers in and around Le Roy had such a high regard for Frank, they pitched in and helped him build his sales and service building, shown below. Frank is past president of the Genesee Valley Implement Dealers' Association.

"Any way you look at it, selling high compression is sound business,"

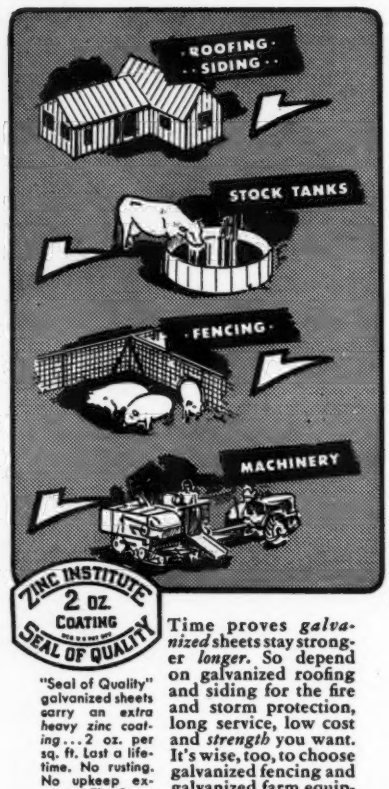
says ***Frank W. Bickford,***
Massey-Harris dealer of Le Roy, N. Y.

"Every time I sell a high compression tractor I make a friend. Once a customer puts a high compression model on his farm, I know he will find that it lives up to everything I said about it—and then some!

"I find that the chief reason farmers are so pleased with our Massey-Harris high compression models is that these tractors give them the *power* they want. But there are other important advantages, too. Gasoline-operated tractors give faster starting, quicker warm-ups, smoother idling and cleaner burning of fuel. When I have customer after customer tell me how pleased he is with his new high compression tractor, I know my business is on firm ground."

Tractor dealers who push high compression tractors are building their business . . . because farmers everywhere appreciate the better performance and extra power that gasoline-operated tractors deliver. That's why more than eighty percent of the tractors being manufactured today have high compression engines.

Only
GALVANIZED SHEETS
GIVE THE
STRENGTH OF STEEL
PLUS THE RUST
PROTECTION OF ZINC



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(Continued from page 412)

Graham Head Nat'l Council Student Branches

NEW officers of the National Council of ASAE Student Branches were elected at the last business session of the student group meeting held at the Hotel Statler, Washington, D. C., in conjunction with the 43rd Annual Meeting of the Society. James Graham of Purdue University was installed as president of the Student Council for the coming year. Other officers elected were Tom King, Iowa State College, first vice-president; John Pederson, Cornell University, second vice-president; and Joe Turner, University of Georgia, secretary.

Over half of the colleges at which ASAE Student Branches are established were represented among the eighty students who were in attendance at the meeting. The student program was arranged to allow the students to attend the technical sessions of the ASAE Annual Meeting in the mornings, and also enabled them to participate in the special tours and trips in the afternoon.

Hawaii Section Meeting Program

THE Hawaii Section of the American Society of Agricultural Engineers met on June 26, at the University of Hawaii, with 25 members and guests present. John F. Cykler of the University agricultural engineering staff gave a demonstration of the unit Napier grass harvester, after which the group retired to the conference room for further discussion.

T. W. Bohmker, representative of Deere and Co., discussed the position and developments of his company as related to the mechanization of the sugar industry.

PERSONALS OF ASAE MEMBERS

Walter Bergstrom, graduate student in agricultural engineering of the State College of Washington, recently received appointment as irrigation engineer of the Irrigation Equipment Co., Eugene, Ore. His work will include design and sales of sprinkler irrigation systems in the Northwest.

Roger M. Cleveland has resigned as assistant professor of agricultural engineering, University of Arkansas, to engage in farming near Webster City, Iowa, and also to serve as veterans-on-the-farm-training instructor in the Webster City public schools.

C. E. Frudden, consulting engineer, tractor division, Allis-Chalmers Mfg. Co., was recently awarded the Marston Medal by Iowa State College. The medal is awarded annually to an engineering alumnus of Iowa State College in recognition of achievement in engineering.

Dean K. Fuhriman is now doing graduate work and serving as research assistant in the hydraulics department of the University of Wisconsin.

Robert L. Green, assistant professor in agricultural engineering, Louisiana State University, is presently on leave of absence and is taking graduate work leading to an advanced degree at Michigan State College.

Frank P. Hanson, assistant merchandise manager for several years for the Caterpillar Tractor Co., has recently been transferred to the Company's engineering department with the title "agricultural engineer". In this change the benefits of Mr. Hanson's broad experience will be made available to the Company's engineering department for the study and solution of its engineering problems as related to agriculture. It will also permit him to continue many of his present activities related to the Company's interest in the field of agriculture.

Robert B. Huey, formerly farm consultant on farm structures to the Badger Lumber Co., at Marion, Kans., is now manager and vice-president of Mid-Continent Industries, Inc., Hutchinson, Kans. In his new position he will have supervision of maintenance and repairs for the Naval Air Station at Hutchinson.

Andrew Koski, Jr., a 1949 graduate of the University of New Hampshire, is now employed as superintendent of irrigation (of sugar cane) for Luce and Co., Aguirre, Puerto Rico.

John L. McKitrick is on leave from his position as extension agricultural engineer for the University of Kentucky to serve as head of the engineering staff of the Reynolds Farm Institute, recently organized by the Reynolds Metals Co., Louisville, Ky.

H. P. Smith, professor of agricultural engineering, A. & M. College of Texas, is presently on leave, and is serving as a special advisor on farm machinery to the Ministry of Agriculture of Turkey, in connection with a special mission of the ECA to that country.

Clyde Walker is now employed as agricultural engineer by the Portland General Electric Co., Portland, Ore., having sold his interest in a retail farm equipment business in which he has been engaged for some time.

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Nickel Alloy Steel Gears

There are two kinds of nickel alloy steel gears . . . those that are carburized, and those that are direct hardened.

CARBURIZED GEARS

The carburized gear is used in applications that require maximum wear resistance in the surface, as well as greatest surface compressive strength. With nickel alloy carburizing steels, this goal is consistently attained, together with development of extremely tough cores that resist shock loads, fatigue and bending stresses. Moreover, a chief cause of noisy gears . . . the distortion that accompanies heat treating . . . is inherently resisted by nickel alloy carburizing steels.

DIRECT HARDENED GEARS

The direct hardened steel gear is used to carry heavy tooth loading in applications where resistance to wear and surface compressive stresses is not quite so vital a factor. Here again, the nickel-containing steels develop the required strength more consistently and in heavier sections than carbon steels, and are generally more resistant to shock, fatigue and multi-axial stresses. Distortion resulting from heat treatment may be minimized by using nickel alloy steels and their machinability before final heat treatment is very good.

Giving greater play to the skill of the engineer, nickel alloyed steels not only provide increased strength without sacrificing ductility, but they harden at lower temperatures which simplifies heat treatment and minimizes deformation and scaling.

MEET VARIED REQUIREMENTS

Nickel alloyed steels enable producers to meet virtually any reasonable requirements . . . whether dictated by revised stress analysis due to design changes, or by changed fabricating methods that demand better machining qualities or improved response to heat treatment.

MANY TYPES AVAILABLE

The many standard grades of nickel alloyed steels permit specifying the particular type which provides the best set of properties for any reasonable fabrication and service demands.

Unending competition for higher speeds and heavier loads, for quieter operating and longer machine life, provide opportunities for gear producers to drive ahead with nickel alloyed steels. Use the coupon for your copy of "Modern Trends in Nickel Steel and Cast Iron Gear Materials." This useful and informative booklet is yours for the asking. Send for it now.

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Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Alam, S. M.—Dept. of agr., State of Bihar, India. (Mail) Agr. Eng. Dept., University of Wisconsin, Madison 6, Wis.

Atkinson, Frank W., Jr.—Service engr., John Deere Plow Co. (Mail) Chamblee, Ga.

Barnell, Leo C.—Trainee, Farmers' Union State Exchange, Omaha, Nebr. (Mail) 332 South 37th St.

Barnes, Samuel H.—Agr. engr., Central Power & Light Co., Corpus Christi, Tex.

Bawel, Fred W.—415 North 4th St., Boonville, Ind.

Blum, George B., Jr.—Instr. in agr. eng., North Carolina State College, Raleigh, N. C.

Brooks, Tauno O.—Res. asst. in agr. eng., University of Maine, Orono, Me.

Burch, Irven R.—Sales and serviceman, farm machinery dept., Brown & Burch, Giddings, Tex. (Mail) Box 509

Campbell, Donald J.—Jr. engr., J. I. Case Co. (Mail) P. O. Box 1848, Stockton, Calif.

Coates, Edwin S.—Ext. agr. engr., North Carolina State College, Raleigh, N. C.

Cowart, Andrew—Trainee, Great Lakes Steel Corp., Stran-Steel Div. (Mail) R. R. 1, Garfield, Ga.

Daniel, Thomas M.—Agr. engr., SCS, USDA. (Mail) R.R. 2, Garland, Tex.

Desautels, Herman J.—Eng. aid, BPISAE, USDA. (Mail) 403 No. 1st St., East Grand Forks, Minn.

Detroy, Benjamin F.—R. R. 1, Springerton, Ill.

Dooley, John W.—Asst. engr., Knox Co. Rural Electric Membership Corp., Vincennes, Ind. (Mail) 612 Broadway St.

Dutz, Hans G.—Graduate student, agr. eng. dept., Iowa State College, Ames, Iowa

Dye, John R.—Whitestown, Ind.

Edwards, Lacy L., Jr.—General sales mgr., Atkinson Pontiac & Implement Co., Inc., Marion S. C. (Mail) Box 836.

Ethelman, Richard K.—Advisor, Southern Nebraska Rural Public Power, P. O. Box 766, Grand Island, Nebr.

Fokes, Jack M.—Sales trainee, Caterpillar Tractor Co., Peoria, Ill. (Mail) 210 Archer St.

Freeman, Berkley I.—Agr. engr., Clackamas Co. PMA, USDA. (Mail) 660 McLaughlin Blvd., Gladstone, Ore.

Garvin, Paul M., Jr.—Asst. ext. agr. engr., Clemson College, Clemson, S. C.

Gilman, Paul A.—Asst. prof. of farm mechanics, University of New Hampshire, Durham, N. H.

Givens, Frank S., Jr.—Asst. agr. engr., State Corporation Comm., P. O. Box 1197, Richmond 9, Va.

Gravely, John O. W.—Zone mgr., The Doolittle Tractor & Implement Co. (Mail) 411 West 3rd St., Ayden, N. C.

Grimm, Roy H.—Salesman, irrigation dept., Standard Fertilizer Co., Inc. (Mail) Butner, N. C.

Haak, Willard J.—428 36th St., N. E., Cedar Rapids, Iowa

Hanson, Kenneth L.—R. R. 1, Jamestown, Kans.

Harrington, Roy E. — Student engr., product dev. dept., Deere & Co., Moline, Ill. (Mail) 2525 33rd St.

Hollopeter, Frank R.—R. R. 4, Albion, Ind.

Huneke, Clifford G.—R. R. 3, Osgood, Ind.

Hurst, Homer T.—538 E. Town St., Columbus 15, Ohio

Hussey, Basil L.—Salesman, Pump Service Co., Twin Falls, Ida. (Mail) 312 4th Ave., E.

Hyman, Benjamin M. — Design engr., International Harvester Co. (Mail) R. R. 2, Box 151, East Moline, Ill.

Johnson, LaRue N.—R. R. 3, Orleans, Ind.

Kash, Louis J.—Walter T. Dunlap Co. (irrigation contractor), Lexington, Nebr. (Mail) 1104 Jackson

Kast, Laverne A.—Special agent, farm dept., The Home Insurance Co., 320 N. Meridian St., Indianapolis 4, Ind.

Kherdekar, D. N.—Extra-asst. director, in charge agr. eng. res., Govt. Dept. of Agr. (Mail) Madhya Pradesh, Nagpur, India

Lawrence, Allan K.—Res. fellow in agr. eng., Rutgers University, New Brunswick, N.J.

(Continued on page 418)

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DRAIN PLUG
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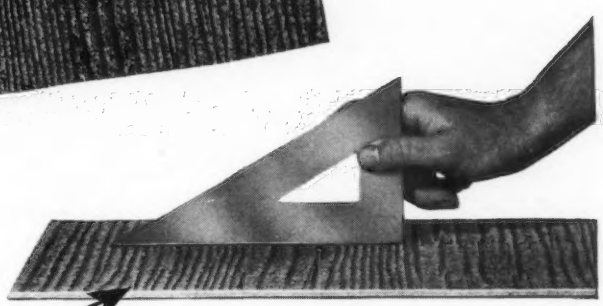
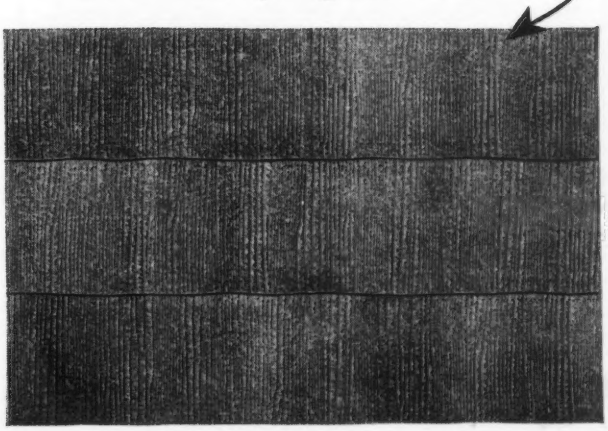


Smooth surface... no grooves... yet beautifully "grained"!



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These new *Smoothgrain* asbestos shingles are *stronger* because they have the same cross section throughout . . . they *cut cleaner* because the shingle cutter always works against a smooth surface . . . they *resist soiling* better and always look the same from any angle, because they have no grooves, no raised texture to catch dirt or highlights and thus distort appearance.

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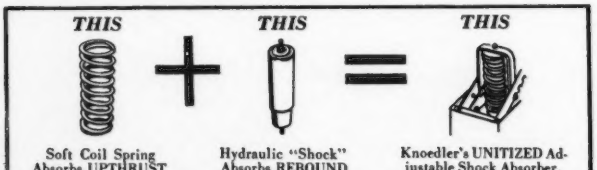

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APPLICANTS FOR MEMBERSHIP

(Continued from page 416)

Levine, Gilbert—Graduate asst. in agr. eng., Cornell University, Ithaca, N. Y.

Lord, John F.—Supt. of agr., United Fruit Sugar Co., Banes, Oriente, Cuba

Lucius, Frank C.—Asst. mgr., Family Loan Co. (Mail) 200 Greenwood Dr., West Palm Beach, Fla.

Lynn, Herman P.—Asst. ext. agr. engr., Clemson College, Clemson, S. C.

McBrayer, James H., Jr.—Sales engr., irrigation dept., Standard Fertilizer Co., Inc. (Mail) 802 Green St., Apt. E-4, Durham, N. C.

McElhinney, Warren W.—Farmer, Potomac Oak Farm, Dysart, Iowa

Mercer, Angus W.—Sales engr., Contractors Service, Inc. (Mail) R. R. 2, Pink Hill, N. C.

Mills, Donald J.—Junior engr., Electric Power Board of Chattanooga, Chattanooga, Tenn. (Mail) 307 Glenwood Dr.

Osborn, Burton L.—Farm structures advisor, Allen Co. Lumber Co., 2236 Wayne Trace, Ft. Wayne, Ind.

Patterson, Joseph M.—Proj. and res. engr., John Bean Div., Food Machinery & Chemical Corp. (Mail) 301 E. Middle St., Williamston, Mich.

Rauth, Glen E.—Truck farm mgr., R. R. 5, Boonville, Ind.

Rhoads, Robert B.—Graduate student, University of Maine. (Mail) 11 Catell St., Bangor, Me.

Rice, Lloyd A.—Asst. to head of pump dept., Western Land Roller Co., Hastings, Nebr. (Mail) 1411 West 5th St.

Richter, Donald W.—Graduate student in agr. eng., Cornell University, Ithaca, N. Y. (Mail) 312 Thurston Ave.

Rock, Randel A.—Agr. asst., Gibson Galeener Co., St. Jacob, Ill.

Sanders, Merret B.—Asst. service supervisor, International Harvester Co. (Mail) 640 Monroe, Quincy, Ill.

Sauer, Gilbert F.—Graduate asst. in agr. eng., University of Illinois. (Mail) Fisher, Ill.

Schacht, H. Rosenstand—Head, agr. eng. dept., Royal Agr. College. (Mail) Bulowsvej 13, Copenhagen West, Denmark

Schaller, Harry D.—Asst. service supervisor, International Harvester Co. (Mail) Elks Club Hotel, 77 Stolp Ave., Aurora, Ill.

Shirey, Milton L.—Rural sales mgr., Noland Co., Inc., Newport News, Va.

Skeen, Joseph R.—Soil conservation engr., United Pueblos Agency, Indian Field Service, USDI. (Mail) Zuni, N. M.

Smith, John H.—Asst. supt. of agr., Banes Div., United Fruit Sugar Co., Banes, Oriente, Cuba

Soiland, Marvin K.—Trainee, Caterpillar Tractor Co. (Mail) 118 N. Institute Pl., Peoria 5, Ill.

Stahl, Ervin H. A.—Trainee, Layne-Northern Co. (Mail) R. R. 2, Brownstown, Ind.

Steury, Howard C.—Engr. trainee, J. I. Case Co. (Mail) R. R. 1, Berne, Ind.

Swift, David J.—Junior engr., Drake Puget Sound Construction Co., Seattle, Wash.

van Schilfgaarde, Jan—Res. fellow in agr. eng., Iowa State College, Ames, Iowa

Wablin, F. W.—Pres. and chief engr., Spraying Systems Co., 3201 Randolph St., Bellwood, Ill.

Waite, Robert A.—401 32nd St., W., Bradenton, Fla.

Wakeland, Howard L.—Agr. engr., State Water Survey, Box 717, Peoria, Ill.

Williams, Donald R.—R. R. 1, Mt. Sterling, Ill.

Williams, Hubert H.—Agr. engr. and electrical advisor, Chickasaw Electric Cooperative, Somerville, Tenn.

Wilson, Jerome J.—Draftsman, agr. eng. dept., Louden Machinery Co., Fairfield, Iowa. (Mail) 301 S. Court

Winterfield, Harold J.—Veterans' instructor in farm training, Milbank City Schools, Milbank, S. D. (Mail) 226 North 2nd St.

Young, Allan L.—Conservation engr., Warm Springs Indian Agency, Bureau of Indian Affairs, USDI. (Mail) Club House, Warm Springs, Ore.

TRANSFERS OF MEMBERSHIP GRADE

Dudley, Richard F.—Asst. agr. engr., Miss. Agr. Exp. Sta., State College, Miss. (Mail) Box 175 (Junior Member to Member)

Nordahl, Ole C.—Sales engr., Rilco Laminated Products, Inc. (Mail) P. O. Box 815, Wichita, Kans. (Junior Member to Member)

Payne, James E.—Soil conservationist, SCS, USDA. (Mail) Jackson, Ga. (Junior Member to Member)

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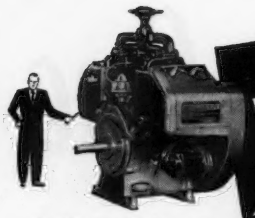

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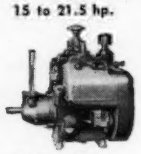
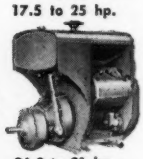


17.5 to 25 hp.

V VP-4



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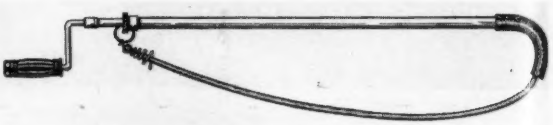
Nickel Alloy Technical Bulletins. The International Nickel Co., 67 Wall St., New York 5, N. Y., has issued two new technical bulletins on the engineering properties of high nickel alloys, free copies of which will be sent on request. Both are 24 pages in length and contain charts, tables on compositions and properties, working instructions, and other information of a technical nature. While each of the bulletins represents, to some extent, revisions of earlier bulletins on the same subjects, the revisions have been so complete and the new data contained so extensive that they are essentially new presentations. Technical Bulletin T-7, entitled "Engineering Properties of Inconel," contains, in addition to information on Inconel, material on Inconel "x", one of the newer age-hardenable Inco nickel alloys. Technical Bulletin T-9 deals with the engineering properties of "K" Monel and "KR" Monel.

• • •

Stow Sani-Auger. Stow Mfg. Co., Binghamton, N. Y., announces a new product, the Stow Sani-Auger, which quickly clears toilet stoppages. The Sani-Auger features a unique telescoping-body into which the durable Stow multicoil flexible shaft can be drawn. By pulling the crank-arm out, the flexible shaft is retracted into the tube. This prepares the Sani-Auger for insertion into the bowl. The rubber wrapping on the curved end of the tube prevents damage to the fixtures. When the auger is in place, merely push down on the handle and the flexible shaft is extended down through the pipe to the stoppage. The spiral tip with which the shaft is fitted, engages the stoppage at the turn of the crank, and the obstruction is thus quickly cleared.



Stow Sani-Auger

(Continued on page 422)

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RATES: Announcements under the heading "Professional Directory in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

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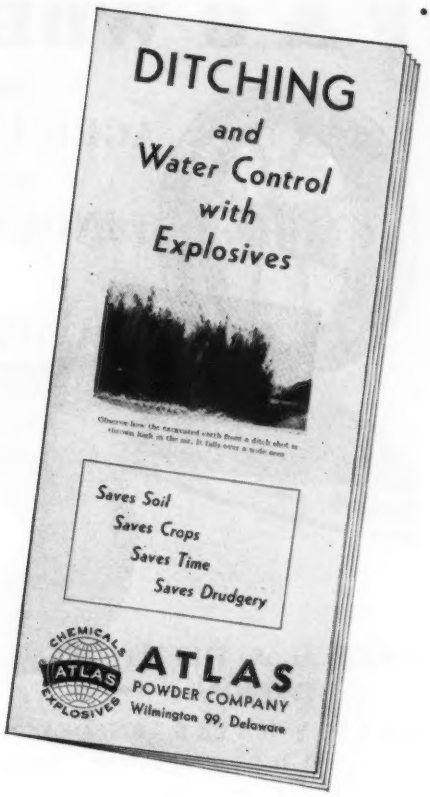

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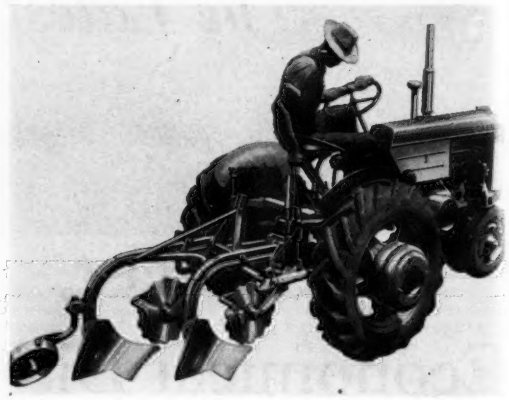
NEWS FROM ADVERTISERS

(Continued from page 420)

Case 3-Point Hitch. The J. I. Case Co., Racine, Wis., recently announced the Eagle hitch, a simple and entirely new 3-point hitch on their low-cost 2-plow VAC tractor. The company also announced a complete selection of new latch-on mounted implements for use with the Eagle hitch, all controlled by an entirely new low-pressure hydraulic unit. In the illustration the driver "latches on" to a plow without getting off the tractor seat; then he slips in one pin and at a touch of the

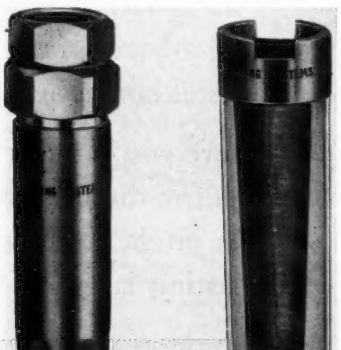


The Case three-point hitch

control lever raises the plow and is on his way. Advantages claimed for the Eagle hitch are: (1) the farmer can hitch up to an implement in a minute or less without getting off the tractor seat; (2) control of the implement in the field is fast and accurate; (3) implement works at an even depth in spite of hard and soft spots in the ground.

• • •

Spraying Systems Strainers. Spraying Systems Co., 3226 Randolph St., Bellwood, Ill., announces two strainers designed to give operating efficiency at low unit cost. The ¾ Q Line Strainer is made of brass with welded monel metal screen and is recommended for installation on spray rigs of any type or spraying capacity. It will operate at pressures up to 600 psi and should be installed in the line between the pump and the spray boom. Generally it is recommended that the con-



Spraying Systems ¾ Q line strainer (*left*) and 1-QSW suction strainer (*right*)

nection from the strainer to the boom be made with a rubber hose. The 1-QSW Suction Strainer consists of a welded monel metal screen and screen retainer and is designed for installation in a one-inch suction pipe. Both strainers afford exceptionally large screening areas. For complete information write the company for Data Sheets 4658 and 4659.

New Bulletins

Your Future's in the Bag. The National Fertilizer Association (616 Continental Bldg., Washington, D. C.) An illustrated 36-page, 8½ x 11-inch bulletin in color telling in simplified, popular, non-technical form the story of the value of commercial fertilizer to food consumers as well as to food producers.

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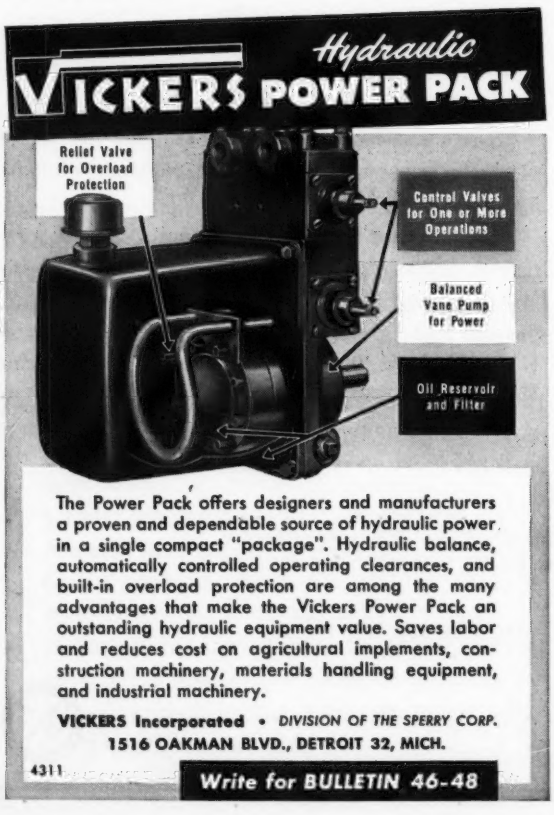
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Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated:

POSITIONS OPEN: (1949): AUGUST—O-34-675. NOVEMBER—O-127-690. (1950): JANUARY—O-189-692. MARCH—O-262-700, 262-701. JUNE—O-355-717, 379-718, 393-719, 395-720, 407-721. JULY—O-360-722, 396-723, 418-724, 418-725, 421-726.

POSITIONS WANTED: (1949): JULY—W-13-299. SEPTEMBER—W-67-312. OCTOBER—W-111-316. DECEMBER—W-145-323, 146-324. (1950): JANUARY—W-164-331, 175-334, 179-335, 190-338. MARCH—W-227-351, 247-352, 228-353, 256-355, 257-359, 246-360, 268-361, 258-362. APRIL—W-294-368, 304-370, 291-373, 307-375. MAY—W-320-376, 327-377, 328-378, 333-380, 338-383, 339-384, 349-385, 351-386. JUNE—W-348-391, 366-392, 364-393, 384-395, 383-397, 387-399, 274-400, 369-401, 378-402, 354-403, 394-404. JULY—W-400-406, 402-407, 382-408, 337-409, 398-411, 414-412, 412-413, 410-414, 417-415.

NEW POSITIONS OPEN

RESEARCH ASSISTANT for one-half time cooperative work with local manufacturer on the development of spraying equipment; half-time work toward MS deg in a landgrant college in the Southwest. BS deg in agricultural engineering, or equivalent. Interest in farm power and machinery. Good health. Opportunity up to individual. Age 20-35. Salary $115 per month. O-21-501

GRADUATE FELLOW for half-time teaching and half-time work for MS deg in a landgrant college in the Southwest. Opportunity for research to fulfill thesis requirement in farm power and machinery, soil and water conservation, or farm structures. BS deg in agricultural engineering, or equivalent. Good health. Age 20-35. Salary $100 per month. O-21-502

ENGINEERING EXECUTIVE, top grade, to direct oil processing, power house plants, fertilizer and chemical laboratories of a plantation and processing industry in Northern Florida. Engineering and farm background. Age 35-45. Salary open. O-25-503

AGRICULTURAL PRODUCTION EXECUTIVE to supervise operation of some 10,000 acres with one major crop and some diversified crop and livestock production, in northern Florida. Farm background and managerial experience. Age 35-45. Salary open. O-25-504

ASSISTANT PROFESSOR of agricultural engineering for ¾-time teaching farm machinery and shop courses; ¼-time research in farm machinery, in a landgrant college in the Northeast. MS deg in agricultural engineering or equivalent. Some experience in teaching or research preferred. Usual personal qualifications for college work. Normal opportunity for advancement. Appointment on 12-month basis with one month vacation. Age 25-35. Salary $4200 range. O-31-505

NEW POSITIONS WANTED

DESIGN, development, or research in assistantship or similar opportunity for study toward an advanced degree in a college in the U.S. Power and machinery or farm structures field. BS deg in agricultural engineering, 1950, Allahabad Agricultural Institute. Presently employed as assistant engineer in sales and service work with a farm equipment dealer in Calcutta, India. Single. Age 22. No disability. Available on short notice plus allowance for travel time. Salary $1200. W-5-1

EXTENSION, teaching, or research in soil and water field in public service or private industry, preferably in Southwest or West. BS deg in agricultural engineering, 1949, New Mexico A & M College. MS deg in agricultural engineering expected in August, Utah State Agricultural College. Irrigated farm background. Aircraft electrical specialist, 2 yr. Research fellow, irrigation and drainage, one year. War noncommissioned service, Army Air Force, over 2 yr. Single. Age 24. No disability. Available Sept. 1. Salary open. W-4-2

EXTENSION, teaching, or research in rural electrification, with public service agency, preferably in Northeast. BS deg in agricultural engineering, 1950, Rutgers University. Farm background. Several months as bench worker in a machine shop producing surgical and optical instruments. Electrician's apprentice, one year. Laboratory technician one year, doing mostly control testing of plastic sheeting. Familiar with standard laboratory procedure. War enlisted service with duty as topographic surveyor and chief computer. Single. Age 27. No disability. Available in September. Salary $3000. W-11-3

DEVELOPMENT, research, or sales in power and machinery or rural electric field with manufacturer anywhere in the U.S. BS deg in agricultural engineering, 1950, University of Missouri. Farm background and experience in repair of machinery. War service in Navy as gunnery instructor. Single. Age 25. No disability. Available now. Salary open. W-12-4

DESIGN, sales or service in farm structures or soil and water field with manufacturer or distributor, preferably in Midwest or West. BS deg in agriculture 1948, both at University of Wisconsin. Farm background. Operated motor road grader 8 mo while in Army. War noncommissioned service in aviation engineers over 3 yr, classification heavy equipment sergeant. Married. Age 29. No disability. Available now. Salary $275 mo. W-26-5